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THE COMMITTEE ON ENGINEERING DEGREES

By DEAN O. M. LELAND

University of Minnesota

The Committee on the Titles of College Degrees in Engineering was appointed by President Wickenden in 1933, consisting of Deans Fred E. Ayer, University of Akron; Geo. W. Case, University of New Hampshire; S. B. Earle, Clemson Agricultural College of South Carolina; Louis Mitchell, Syracuse University; Geo. C. Shaad, University of Kansas; and the writer, as chairman.

The following brief report of the committee was presented to the Council and the Society at the Ithaca meeting in June, 1934, together with supporting statements and explanations. Upon the recommendation of the Council, the report was carried over to the 1935 meeting, with the understanding that it would be brought to the attention of the membership by publication in the JOURNAL for consideration in advance of the meeting.

REPORT OF THE COMMITTEE ON DEGREES IN ENGINEERING

Although a standard system of engineering degrees has been sought by this Society for many years, and three separate committees previous to this one have considered the question and submitted reports, in 1910, 1918, and 1920, a wide variation in practice still exists. In each case the committee has recognized the desirability of a uniform system and has hoped that a further consideration of the subject would bring about the desired result. The report of 1920 concludes: "Although our committee has not been able to reach unanimous opinions on the above points, we recommend the standardization of degrees given in engineering by the various American colleges, as far as may be practicable."

Using civil engineering as the typical example with the understanding that other branches such as mechanical, electrical, chemical, mining, etc., would be used in a corresponding manner, the following forms of the first, or bachelor's degree in civil engineering are in use:

Bachelor of Arts,
Bachelor of Science,
Bachelor of Science in Engineering,

Bachelor of Science in Civil Engineering,
Bachelor of Engineering,
Bachelor of Civil Engineering,
Civil Engineer.

Since 1920, significant actions have been taken which indicate a tendency to compromise upon an intermediate form. Several colleges have abandoned the degree of bachelor of science in civil engineering or the degree of civil engineer for bachelor of civil engineering. Last year, a conference of representatives of engineering schools in the State of New York and the State Board of Examiners of Professional Engineers, in conjunction with the State Education Department, went on record in favor of the use of the degree, bachelor of civil engineering, with corresponding forms for the master's and doctor's degrees. Therefore, the present committee took up its work with a reasonable prospect of success.

The committee unanimously approves the following *principles* as a basis for all earned collegiate degrees in the field of engineering:

(*a*) Each degree should include the word bachelor, or master, or doctor, in order of advancement. (These are recognized forms in general use by colleges.)

(*b*) Each degree should include the name of the particular branch of engineering in which the major work is taken. (The professional nature of the degree is thus made evident.)

If the major work is in general scientific and fundamental subjects related to engineering but not primarily in a single professional field, the word *science* may appropriately be used, as bachelor of science, or bachelor of applied science.

In accordance with these principles and after careful consideration of the question in all of its phases and its historical background, the committee submits the following plan and unanimously recommends its approval by the Society, with the understanding that action in conformity with the plan is optional on the part of any institution:

(1) The bachelor's degree resulting from the completion of a professional curriculum in engineering should be of the type, Bachelor of Civil Engineering (B.C.E.).

(2) The master's degree in engineering should be of the type, Master of Civil Engineering (M.C.E.).

(3) The doctor's degree in course in engineering should be of the type, Doctor of Civil Engineering (D.C.E.).

(4) For curricula in general scientific or fundamental engineering subjects not primarily professional in character, the degree bachelor of science is appropriate, to be followed logically by master of science and (or) doctor of science or philosophy. (Applied science may be used if preferred.)

(5) The professional degree, Civil Engineer, etc., should be abandoned by educational institutions, both as an earned degree and as an honorary degree.

(6) Honorary degrees in engineering should be limited to the two forms, Master of Engineering (M.Eng.) and Doctor of Engineering (D.Eng.). Neither should be used in any other sense than as an honorary degree.

Respectfully submitted,

FRED E. AYER,
GEO. W. CASE,
S. B. EARLE,
LOUIS MITCHELL,
GEO. C. SHAAD,
O. M. LELAND,
Chairman.

DEGREES, IN GENERAL

A degree as an index of achievement or honor is usually awarded by an educational institution. Degrees *in course* are earned by the completion of studies or other scholastic requirements generally wholly or partly in residence at a college or university. Honorary degrees, on the other hand, are awarded as a result of noteworthy achievement in public, private, or professional life for which the objective is not the degree. While there are a few exceptions, degrees are usually awarded by educational institutions and have come to be regarded as belonging to the colleges and universities.

Three ranks or grades of the earned degrees are universally recognized, namely, the bachelor's, the master's, and the doctor's degrees. These words have fairly definite meanings. The bachelor's degree is usually the first one received and corresponds to the completion of a course of study embracing four or five years following graduation from high school. The master's degree is the second one to be earned and follows the bachelor's degree after one or two years of graduate study. The doctor's degree usually requires three or four years of graduate work after the bachelor's degree or two or three years after the master's degree.

The remaining words or abbreviations in a degree are intended to indicate the field of study in which the student has carried on his work to earn the degree. In the days when colleges were devoted primarily to the classics, the customary degree was Bachelor of Arts. The advent of scientific studies brought the degree Bachelor of Science for students devoting special attention to the sciences. These two degrees are in common use at the present day.

With the development of college courses for training in the professions, special degrees were devised to indicate these profes-

sions. The ministry, law, and medicine were followed by an increasing number of recognized fields corresponding to the specialization resulting from the advancement of knowledge and the complexity of modern life. Insofar as these professions required college preparation and training, new degrees were introduced from time to time by various schools while others clung tenaciously to the old academic forms, notwithstanding the fact that these latter failed to convey the definite meaning which they should carry. Thus, as indicated in the list above, the unqualified degrees of Bachelor of Arts and Bachelor of Science are still in use at certain schools for a course in civil engineering. In other colleges various qualifications are placed upon the degree to make it more definite, such as Bachelor of Science in Engineering and Bachelor of Science in Civil Engineering, while retaining the academic portion, Bachelor of Science, unchanged.

It is easily understood, therefore, how the form, Bachelor of Science in Civil Engineering, has grown out of the academic degree, Bachelor of Science, which was used in the early days of engineering education when engineering departments were in the arts colleges merely as branches of science or applied science.

The professional character of the various branches of engineering, such as civil, mechanical, mining, electrical, and chemical engineering, cannot be denied. Similarly the courses of instruction in colleges and universities which prepare for the practice of these professions must be recognized as professional courses. It should follow then that the degrees resulting from the completion of these courses should be clearly professional in character. This being the case, the use of the words "Arts," "Science," and "Science in," in these degrees cannot logically be justified.

The same situation exists among the master's degrees for work in engineering, Master of Arts, Master of Science, Master of Science in Civil Engineering, etc., containing words which contribute nothing to the significance of the degrees. Simplicity, directness, and definiteness would demand their omission.

The reasonableness of the principles (*a*) and (*b*) stated in the above report should be evident to all. The use of the words bachelor, master, and doctor for college degrees has been established beyond question. Also, if the degree is to convey definite meaning, certainly it should include the name of the professional curriculum upon which it is based. No other words are necessary. The degree is complete if it contains these two parts. Without either part, it is indefinite and incomplete.

The Bachelor's Degree

The form of the bachelor's degree recommended by the Committee satisfies the requirements indicated above. It is a bachelor's degree. It is an engineering degree. It is a civil engineering degree. One letter, only, is used for each of these three requirements. Thus the degree is simple, direct, definite, and adequate, with no superfluous words or letters. This is the degree recommended by the New York Conference. It has been in use at certain colleges for many years. It has been adopted recently as a satisfactory compromise between the Bachelor of Science or Bachelor of Science in Civil Engineering and the degree, Civil Engineer. The response received by the Committee from the representatives of various schools is favorable. The professional character of engineering curricula is now generally recognized, and many colleges are questioning the appropriateness of the academic form of the degree. Still, the variation among the bachelor's degrees in engineering is as wide as ever.

The proposed degree, Bachelor of Civil Engineering, corresponds to a large number of other professional degrees in use at various schools. For example, Bachelor of Architecture, Bachelor of Medicine, Bachelor of Chemistry, Bachelor of Agriculture, Bachelor of Fine Arts, and Bachelor of Business Administration are well known. The basic principles are recognized in these forms.

For those general engineering or applied science curricula which do not correspond to any one of the separate branches of engineering, the degree, Bachelor of Science or preferably Bachelor of Applied Science or Bachelor of General Engineering could be used. Bachelor of Engineering would be objectionable on account of the use of the degree, Master of Engineering, as an honorary degree. Bachelor of Applied Science could be followed logically by Master of Applied Science and Bachelor of General Engineering by Master of General Engineering without inconsistency. The words "Science in" however, should not appear in any degree in engineering.

The Master's Degree

The objections to the degrees, Master of Science and Master of Science in Civil Engineering, correspond to those enumerated in connection with the bachelor's degrees. They are academic rather than professional in form, indefinite or unnecessarily long. The logical form is Master of Civil Engineering to correspond to Bachelor of Civil Engineering. This follows the recommendation of the New York State Conference and is in use at a number of institutions including some which still use the professional degree, Civil Engineer, instead of the bachelor's degree. Corresponding degrees

of this type are in common use, Master of Architecture, Master of Chemistry, Master of Forestry, etc.

For students who have the engineering bachelor's degree, such as Bachelor of Civil Engineering, and pursue graduate study in one of the fundamental subjects such as mechanics, hydraulics, strength of materials, mathematics, or physics, the degree Master of Science, without designation, should be given rather than the degree Master of Civil Engineering, which latter should require advanced work in the professional field of civil engineering, that is, a major in civil engineering.

The Doctor's Degree

The Committee recommends for the doctor's degree in engineering the form Doctor of Civil Engineering (D.C.E.). This is a logical continuation of the bachelor's and master's degrees. The New York Conference approved this form. At present, the Doctor of Engineering is used as an honorary degree and sometimes as an earned degree. Doctor of Science is used in the same manner. The Committee recommends that one form be used for the earned degree, namely, Doctor of Civil Engineering, etc., and one type, Doctor of Engineering or Master of Engineering for the honorary degrees.

The Doctor of Science or Doctor of Philosophy may appropriately be used for students having the bachelor's or master's degree in one of the branches of engineering but pursuing their studies for the doctorate in fundamental science such as mechanics, hydraulics, mathematics, etc. For advanced work in engineering, however, these degrees fail completely to indicate the field of study.

There has been a tendency at certain institutions to limit all master's degrees to the forms, Master of Arts and Master of Science, and all doctor's degrees to one form, Doctor of Philosophy (excepting, of course, the Doctor of Medicine and Doctor of Dental Surgery which conform to our recommendation). This effort has operated so as to impede progress in connection with doctor's degrees in particular. Undoubtedly, more colleges deviate from this rule than follow it. The master's degree with designation, such as Master of Science in Chemistry, Master of Science in Agriculture, etc., are very common. At the same time qualifications are being added to the Doctor of Philosophy degree, especially in the field of medicine, so that we have Doctor of Philosophy in Surgery, Doctor of Philosophy in Obstetrics and Gynecology, etc.

New forms, also, of the doctor's degree are being introduced which would correspond to the recommended form, Doctor of Civil Engineering. For example, there are Doctor of the Medical Sciences, Doctor of the Science of Law, Doctor of Education, Doctor

of Agriculture, etc. In particular, the number of schools using the degree, Doctor of Education, is rapidly increasing.

The Professional Degree

In arriving at its conclusion to recommend the discontinuance of the professional degree (Civil Engineer, etc.) by engineering schools, the Committee considered many pertinent facts. This degree has undoubtedly been the principal reason for the failure of engineering schools to agree upon a certain type of degree. It is one of the oldest forms of degrees in engineering, but has been abandoned as an earned degree by the great majority of schools. The variety of its meanings results in great indefiniteness. At one end of the list it is used as the first degree instead of a bachelor's degree at the end of a four-year undergraduate course. At the other extreme it is awarded as an honorary degree. Between these extremes the following usages appear: first degree earned at the end of a five-year co-operative course; second degree following a bachelor's degree, based upon one or more of the requirements,—a year of graduate study in residence or in absentia, from one to five years of approved professional experience, a report upon engineering work performed, or an original thesis. Although this degree does not contain the word bachelor or master or doctor, it has nevertheless been considered as an academic degree. This is another carry-over from educational practice of several decades ago.

The discontinuance of this degree as a first degree, in place of the bachelor, is recommended by the New York State Conference and it should be noted that certain colleges of that group have already accepted this recommendation, notably, Rensselaer Polytechnic Institute and Syracuse University. Brooklyn Polytechnic Institute took this action a few years ago, also Lehigh University.

Corresponding degrees in other professions than engineering are unknown. No law school bestows upon its distinguished legal graduates the title of "Lawyer" nor does any medical school confer the degree of "Physician" or "Surgeon" nor any dental school the degree, "Dentist." Even among our own schools the professional degree of "Architect" is singularly out of place, although we do use "Civil Engineer." In many states it is still possible for anyone to place on his letterhead or signboard the words "Civil Engineer" whether or not he ever attended an engineering school or received a college degree.

The argument in favor of the professional degree is that it provides a second degree which may be awarded by a college to its alumni on the basis of experience, together with a thesis or report. This may cultivate interest on the part of a small number of alumni, but if this degree could be abandoned as a first degree, correspond-

ing to the bachelor's, it would hardly seem worth while to continue it as a second degree in this quasi-honorary sense. The master's degree might well be used instead. It would introduce no greater variation or uncertainty than now exists regarding the professional degree. In those cases where graduate study or a thesis is required for the professional engineer degree, a master's degree could appropriately be awarded, such as Master of Civil Engineering, as a partially earned degree, notwithstanding the fact that this same degree would be awarded for a year of graduate study in residence. Where the professional degree is awarded without such requirement, it is in effect, an honorary degree and the proposed Master of Engineering would be appropriate. However, aside from the small group of schools still granting this degree instead of the bachelor's degree, the number of these degrees awarded each year is so small as to be almost insignificant. It would seem that it will soon disappear as a first degree. This being the case, the discontinuance of the degree as recommended by the Committee, would cause little disturbance in our system.

While the professional degree has been considered by the Committee on Professional Recognition of the Engineers' Council for Professional Development in connection with the certification of professional engineers, that Committee is giving consideration to the question of using some other designation to express certification.

Honorary Degrees

Honorary degrees are less definite than those awarded in course. They are primarily honorary, although in a general sense they may convey some indication of a field of interest in which recognition is given. The degree, Doctor of Laws, for example, is universally recognized as an honorary degree but it has no relation whatever to the legal profession. The degrees, Doctor of Humane Letters, and Doctor of Literature, on the other hand, refer to the field of letters.

There is no accepted standard form for honorary degrees in engineering. Similar variation exists among honorary degrees of all kinds. For example, the Doctor of Science and Doctor of Engineering are awarded as honorary degrees in some instances and as earned degrees in others. The Master of Arts is frequently awarded as an honorary degree, although it is universally accepted as an earned degree. This variety of usage might be made more definite, if after each honorary degree the abbreviation "(*hon.*)" were added when the title is abbreviated, or written in full "(honoris causae)" when the title is written out, for example, Doctor of Engineering (honoris causae), D.Eng. (hon.). If certain forms could be used only as honorary degrees such as Doctor of Laws,

it might be unnecessary to add the (hon.), but as a standard practice, the added abbreviation would be helpful.

The Committee recommends for honorary degrees in engineering the Master of Engineering and the Doctor of Engineering, with the idea that all honorary degrees in this field would be limited to these two forms. They should not be awarded as earned degrees, although as suggested above, the Master of Engineering might well replace the professional engineer degree when there is no work requirement in connection therewith. Doctor of Engineering Education would be appropriate as an honorary degree for an engineering teacher or administrative officer.

In its report, dated September 21, 1934, the Committee on Professional Recognition of the Engineers' Council for Professional Development referred to the Report of the S. P. E. E. Committee on Degrees in Engineering and included the following statement:

"In the provisions of the S. P. E. E. Committee report to unify the names of and requirements for the degrees to be given for work done at an institution and for honorary degrees, our Committee on Professional Recognition heartily concurs and suggests that E. C. P. D. urge its adoption as soon as practical as a necessary step in clarifying the indefiniteness of the present situation of a multitude of designations and resultant chaotic meaning."

In the consideration of a systematic plan for the degrees in engineering, it should be kept in mind that the variations among the corresponding *curricula* in universally recognized engineering schools which now use the same degree are far greater than the differences among the titles of degrees which we are trying to reconcile. It follows that the adoption of a standard system of degrees would still permit whatever curricular variations might be desired. Both four- and five-year courses, for example, now lead to the same degree in coöperative as well as in other schools so that even such variations in length of course would not need to be disturbed by changing the form of the degree.

It must be noted that the adoption of these recommendations by the Society for the Promotion of Engineering Education would not compel any school to adopt them. Undoubtedly some institutions would continue their present practice without change. They would be free to do so. However, it does seem likely that a large number of schools would adopt the proposed plan if it were accepted by the Society as evidenced by favorable comments received by members of the Committee.

The Chairman, for the Committee, will welcome comments and suggestions or questions from members of the Society.

PERSONNEL STUDY OF PROSPECTIVE ENGINEERS AMONG CALIFORNIA JUNIOR COLLEGE STUDENTS

By WALTER CROSBY EELLS and MAURICE G. REETZ

Professor of Education, Stanford University, and Instructor in Biology, Fresno High School, Fresno, California

The rapid industrial development in the United States in the present century prior to 1929 created a distinct demand for men in the various engineering fields. The surplus of trained engineers since 1929 only increases the importance of any study which makes an analysis of personnel factors concerning students who are planning on engineering occupations.

What kinds of students are in training? What courses have they taken in high school? When did they make their vocational choice? What is their native ability in comparison with other students? How do the groups planning on careers in the various fields of engineering compare with each other in intellectual ability and in scholastic achievement? The answers to these and related questions should be of significance to employers, to administrators of engineering schools, to guidance officers in the lower schools, and to students themselves contemplating a choice of engineering vocations.

The study reported in this article is of particular significance because it is concerned with students in junior colleges. The rapid growth of the junior college movement is one of the most significant developments in American education during the twentieth century. Over 100,000 students are now enrolled in more than five hundred junior colleges in the United States. One of the functions of the junior college is to offer opportunity for exploratory work at the college level. A large proportion of students who have not previously done so make their vocational choices during the freshman and sophomore years. A study dealing with the vocational groups and types of students enrolled in junior colleges should be of distinct significance.

The Group Studied

In connection with the California Junior College Mental-Educational survey two widely used tests of mental ability and of academic achievement were given to over 10,000 students in forty-

seven California junior colleges, and a considerable amount of personal data was secured from the students themselves and from the registrars of the colleges in which they were enrolled.* One question asked the student to state his intended occupation. In the entire group, omitting special students, there were 9,061 freshmen and sophomores of whom approximately 55 per cent, or almost 5,000, were men. No less than 1,040 of these men, 822 freshmen and 218 sophomores, expressed the definite intention of going into some field of engineering. The present paper is devoted to an intensive study of some of the measurable characteristics of this group of prospective engineers.

Number and Distribution

The first and most striking fact is that over 20 per cent of the general group of men enrolled in junior colleges should be looking forward to engineering vocations when, according to the 1930 census, the 277,335 men reported as engaged in the engineering fields constituted less than one half of one per cent of the male population of the country. While somewhat selective, as are all

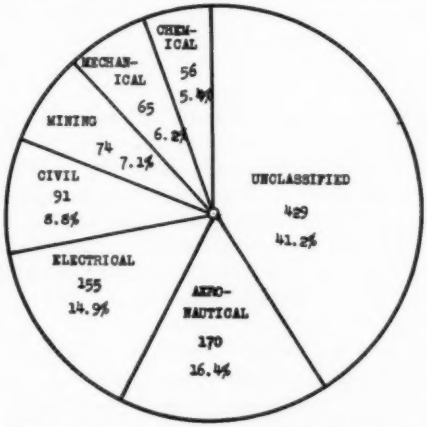

Fig. I. Distribution of prospective engineers in California junior colleges according to fields of engineering.

institutions of higher education, yet an extensive analysis of existing data indicates that the public junior colleges of California are probably the most nearly democratic of any group of our insti-

* Walter Crosby Eells, "California Junior College Mental-Educational Survey" (State Department of Education Bulletin No. J-3), California State Printing Office, Sacramento, California, 1930. 61 pages.

tutions of higher education in the United States.* That many of these students doubtless will never enter the field of engineering does not alter the fact that such was their expressed intention while they were junior college students and that they planned their courses of study accordingly.

The distribution of the 1,040 students according to number and percentage planning to enter each of six important fields of engineering is shown in Figure I. If the 429 students who failed to state the particular field of engineering which they expected to enter are deducted, the percentage distribution of the remainder, in comparison with the percentage distribution of the 277,335 engineers in the country as reported by the 1930 census, is shown in Table I.

TABLE I

PERCENTAGE DISTRIBUTION OF ENGINEERS IN THE UNITED STATES AND OF PROSPECTIVE ENGINEERS IN CALIFORNIA JUNIOR COLLEGES

	United States	California Junior Colleges
Civil engineers	36.7	14.9
Electrical engineers	20.7	25.4
Mechanical engineers	19.6	10.6
Chemical engineers, etc.	16.3	9.2
Mining engineers	4.3	12.1
Aeronautical engineers	2.2	27.8

Marked differences in percentages are found in the two groups, the most striking being in the field of aviation which has the smallest group in the United States but claims the interest and intentions of over a quarter of the prospective California junior college engineers. This western state, too, has three times as large a proportion of prospective mining (including petroleum) engineers as are found in the country as a whole and a somewhat larger proportion of prospective electrical engineers.

MENTAL ABILITY

As a measure of mental ability, the American Council on Education "Psychological Examination for High School Graduates and College Freshmen," 1928 edition, was used. Mean scores made on this test by the total group of freshman prospective engineers and by various other groups for comparison are summarized in Table II.

The prospective engineers, on the average, are seen to be distinctly superior to the average of any of the other general groups, either in California or on a nation-wide basis. Sixty per cent of the prospective engineers are superior to the mean of the general

* H. Dewey Anderson, "Whose Children Attend Junior College," *Junior College Journal* (January, 1934), IV, 165–72.

TABLE II

MEAN SCORES OF VARIOUS GROUPS OF FRESHMEN ON AMERICAN COUNCIL PSYCHOLOGICAL EXAMINATION *

Group	Number of Students	Mean Score	Probable Error of the Mean
Prospective engineers, men, in California junior colleges	816	149.10	1.20
Students, men and women, in 80 privately controlled American colleges and universities	17,244	146.88	0.26
Students, men, in California junior colleges	3,444	138.00	0.59
Students, men and women, in California junior colleges	6,279	137.47	0.43
Students, men and women, in 32 publicly controlled American colleges and universities	13,409	132.62	0.30

* Data, except for the prospective engineers, taken from the "California Junior College Mental-Educational Survey," pp. 13, 52.

group of California junior college freshmen. On the other hand, possibly of greater disturbing significance, is the fact that forty per cent of those who would become engineers are lower in mental ability than the average of their freshman fellows! What are the chances of success in the exacting demands of engineering training and later practice for this large group, 40 per cent of the total, who are not up to the mean of unselected junior college freshmen?

The prospective engineers, however, cannot be considered a homogeneous group in mental ability. Both freshmen and sophomores show marked differences for students looking forward to the various types of engineering. These differences are summarized compactly in graphic form in Figure II, the single cross-hatching showing the freshmen, the double cross-hatching the sophomores. The long bars represent the class as a whole. The cross-hatched portions represent one probable error of the mean laid off above and below the mean test score for each of the component groups, to give a visual method of judging the reliability of the indicated means.

The most striking features of Fig. II are the marked superiority, in both classes, of the prospective chemical engineers and the marked inferiority of those who expect to go into electrical engineering. The group of students who designated "engineering" in general without further qualification rank lower in each class than the average. The sophomore mechanical engineers rank almost as low as the corresponding group among the freshmen, but otherwise there are significant differences between the freshman and sophomore groups. All groups, however, are seen to be above the average

of freshmen junior college men in California, as exhibited in the long bar at the bottom of the chart.

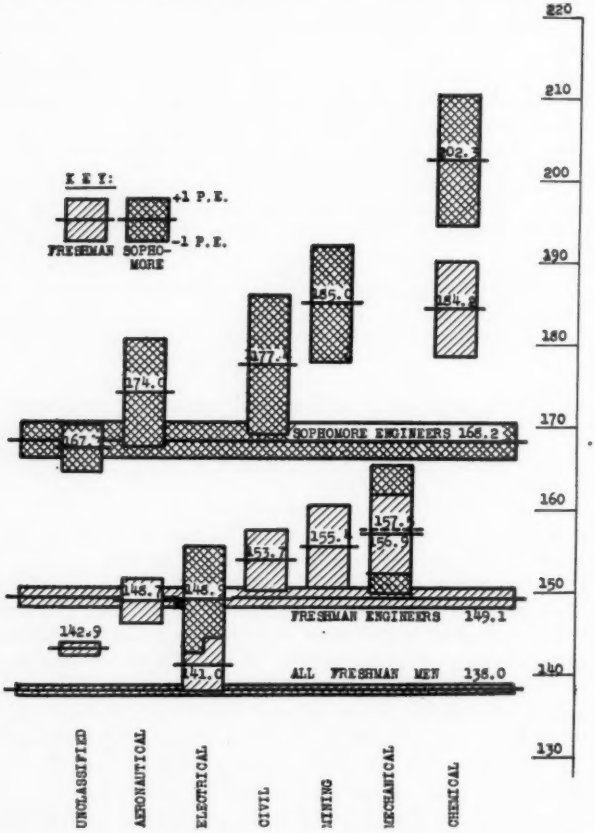

FIG. II. Mean scores on American council psychological examination for California junior college students

The groups having the three highest mean scores (chemical, mechanical, and mining) have the smallest number of students. It would seem, therefore, that the students of lower mental ability tend to select the more popular engineering fields.

Scholastic Achievement

The scholastic achievement in four principal fields of high school study of all the over 10,000 students included in the survey was measured by the "Iowa High School Content Examination," Form B. Results are summarized for the different groups in Figure III, constructed in the same way as Figure II explained above.

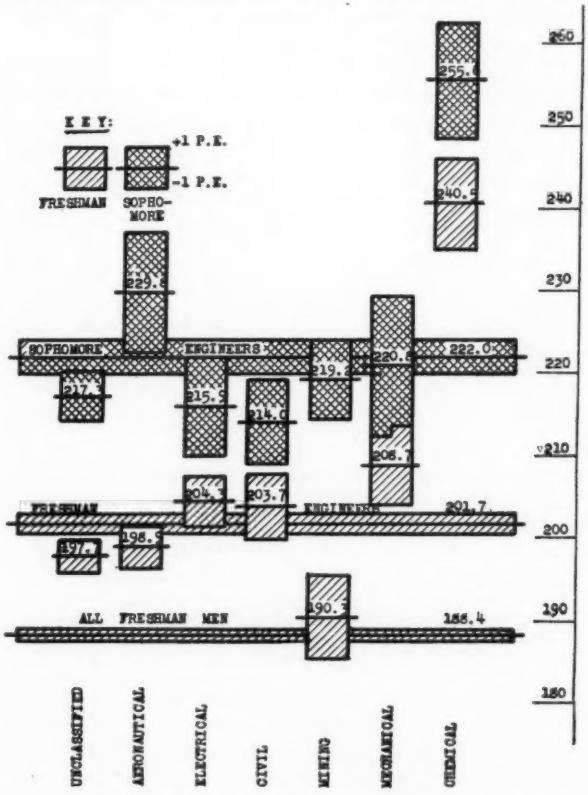

FIG. III. Mean scores on Iowa High School content examination for California junior college students.

The same superiority of engineering students in general over the mean for freshmen as a whole, and the marked superiority in achievement of the prospective chemical engineers is again in evidence.

The Iowa examination is made up of four parts, covering English, history, mathematics, and science. The mean scores of the different groups in the mathematics and science sections, which are most closely related to engineering work, are summarized in Table III.

TABLE III

MEAN SCORES OF CALIFORNIA PROSPECTIVE JUNIOR COLLEGE ENGINEERS IN MATHEMATICS AND SCIENCE SECTIONS OF THE IOWA HIGH SCHOOL CONTENT EXAMINATION, FORM B.

	Number	Mathematics		Science	
		Mean	P.E. of Mean	Mean	P.E. of Mean
Freshmen					
All freshmen men	3,453	34.7	0.2	47.7	0.2
All prospective engineers	814	44.1	0.3	54.0	0.3
Chemical	40	50.2	1.3	66.9	1.3
Civil	69	47.3	1.1	52.8	1.1
Electrical	133	44.9	0.8	55.3	0.8
Mechanical	53	44.6	1.3	55.6	1.3
Unclassified	320	43.7	0.5	57.8	0.6
Aeronautical	144	42.8	0.8	53.8	0.7
Mining	55	39.3	1.2	50.0	1.3
Sophomores					
All prospective engineers	218	52.3	0.5	60.4	0.6
Chemical	16	54.4	1.7	56.9	1.5
Electrical	23	54.2	1.7	62.1	2.1
Civil	21	52.7	2.1	58.7	1.8
Unclassified	104	52.5	0.8	59.8	0.9
Mechanical	12	50.8	2.1	61.7	2.6
Aeronautical	23	50.3	1.3	63.2	2.1
Mining	19	49.9	1.5	62.5	2.0

In the mathematics field, the chemical engineers are distinctly superior among both freshmen and sophomores, with the mining engineers at the bottom in both cases, but with all the engineering groups decidedly above the average for all freshmen men. The relative ranking of the various groups in the two classes is essentially the same.

In the science section, however, the results are somewhat different. The chemical engineers are highest among the freshmen, but lowest for the comparatively small group of sophomores, while the mining engineers are next to the highest. All of the groups of sophomores, however, are rather small in number so that too much

significance cannot be attached to mean scores of groups which in several cases contain less than twenty students each.

Entrance Credits in Mathematics and Science

The number of high school units secured in mathematics and in science is summarized in Table IV, for the 900 students for whom this information was available.

TABLE IV

Number of High School Units in Mathematics and Science Secured by Prospective Engineers in California Junior Colleges.

Units	Mathematics		Science	
	Number	Percentage	Number	Percentage
One or less	36	4.0	176	19.6
1.5 to 2.0	169	18.8	379	42.1
2.5 to 3.0	254	28.2	235	26.1
Over 3.0	441	49.0	110	12.2
	900	100.0	900	100.0

The situation portrayed in Table IV is fairly satisfactory from the mathematics standpoint, although the preparation in this fundamental subject is limited to two units or less (presumably one year each of algebra and plane geometry) for almost one quarter of the engineering students. On the other hand almost half of them have had over three units of high school mathematics which should provide a very satisfactory foundation for college courses in the engineering fields.

The situation is much less commendable, however, in the science field where one fifth of the entire group have had only one year or less of high school science and only one-eighth of the group have had more than three years.

If a great majority of these students decided upon engineering as a vocation prior to their entrance to junior college, as actually was the case (see below), it suggests that their high school guidance left much to be desired in many cases. While of course specialization in engineering or in other fields should not begin at too early a stage in the school career, it certainly would seem that students who are definitely committed to engineering pursuits should have more than the minimum amount of mathematics and science in their high school programs. Certainly the 23 per cent of students whose mathematics has been limited to the bare essentials of elementary algebra and plane geometry, usually taken in the first

two years of high school and largely forgotten if not followed by subsequent mathematics courses, should be very sure of themselves and willing to make up their deficiencies in mathematical and scientific lines before proceeding far in their engineering preparation. It is probable, of course, that many of these with such minimum background in mathematics and science never will achieve their engineering ambitions, although no data are available to indicate the extent of the probable drop-out.

Time of Occupational Choice

From the point of view of vocational and educational guidance, especially in planning suitable courses of study, it is important to know when young men make their vocational decisions. Each student was asked to state when he had made this decision. The answers which were received are summarized for the two classes separately in Figure IV. The question was asked the students within

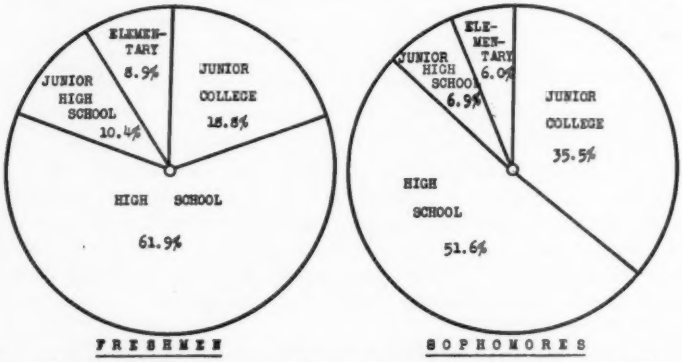

Fig. IV. Distribution of prospective engineers in California junior colleges according to school in which they made their vocational choice.

a month, in some cases within a week, of the opening of college. In view of this fact it is rather significant that as many as 19 per cent, almost one fifth, of the freshmen state that their decision was made in the junior college. For the sophomores the proportion is almost twice as great. What proportion of the freshmen who expect to become engineers may change their minds by the beginning of their sophomore year is purely speculative, but the figures suggest decidedly greater permanence of choice for those at the higher level. The most significant fact, however, is that over three quarters (77.7 per cent) of the entire group state that they made their decision to enter engineering pursuits prior to their entrance to col-

lege—almost a fifth of them (18.0 per cent) in the elementary school or in the junior high school.

In order to investigate the possible relation of mental ability and scholastic achievement to time of making a vocational choice, the mean scores were computed on the American Council and Iowa examinations for the different groups. They are reported in Table V for the largest groups, the Freshmen.

TABLE V

MEAN SCORES ON AMERICAN COUNCIL PSYCHOLOGICAL EXAMINATION AND ON IOWA HIGH SCHOOL CONTENT EXAMINATION FOR FRESHMEN ACCORDING TO TIME OF MAKING VOCATIONAL DECISION.

Time	Psychological			High School Content		
	Number	Mean	P.E. of Mean	Number	Mean	P.E. of Mean
Elementary school	73	150.9	4.3	72	216.8	3.4
Junior high school	85	148.9	3.7	77	198.1	3.7
Senior high school	505	150.2	1.6	476	204.2	1.6
Junior college	153	146.4	2.7	150	188.3	2.7

The differences in mean scores are not highly significant nor consistent in order. There seems to be a slight tendency, however, for the brighter boys, as measured by the psychological test, to make their decisions earlier in life, a tendency which is distinctly more marked in the case of the better students as judged by their actual scholastic achievement in terms of the high school content examination.

INSTITUTIONAL CHOICES

The students were also asked to indicate whether they expected to continue their education after graduation from junior college, and if so, in what institution. Results are summarized for the institutions attracting fifty or more students each in Table VI.

In view of the fact that different institutions require rather specific but often quite different patterns of lower division work for full entrance to their engineering schools at the level of the junior year, it is unfortunate that over a quarter of the prospective engineers had made no decision as to the institution they wished to enter for the completion of their engineering training. Perhaps this is not so surprising for the freshmen, just entering (27 per cent), although they doubtless could plan their junior college courses better if they had a definite institution in view, but the situation is almost as bad for the sophomores, 20 per cent of whom had not selected an institution for further education.

TABLE VI

INSTITUTIONAL CHOICES FOR FURTHER EDUCATION MADE BY PROSPECTIVE ENGINEERING STUDENTS IN CALIFORNIA JUNIOR COLLEGES.

Institution	Number	Per cent of total
University of California, Berkeley	218	21.1
California Institute of Technology	135	13.1
Stanford University	130	12.6
University of California, Los Angeles	116	11.2
University of Southern California	57	5.5
Other institutions	113	10.9
Institution undecided	264	25.6

When the average test scores, both on the psychological examination and on the high school content examination, were computed for the groups planning on subsequent attendance at the different institutions, very significant differences appeared, as summarized in Table VII.

TABLE VII

MEAN SCORES ON THE AMERICAN COUNCIL PSYCHOLOGICAL EXAMINATION AND ON THE IOWA HIGH SCHOOL CONTENT EXAMINATION FOR FRESHMEN ACCORDING TO INSTITUTION SELECTED FOR CONTINUANCE OF THEIR ENGINEERING EDUCATION.

	Psychological			High School Content		
	Number	Mean	P.E. of Mean	Number	Mean	P.E. of Mean
Total	816	149.1	1.2	775	201.7	1.2
California Institute of Technology	122	163.5	3.2	123	219.0	2.9
Stanford University	87	159.5	3.6	82	221.8	3.6
University of California, Los Angeles	102	144.9	3.6	99	195.4	3.5
University of California, Berkeley	156	143.0	2.8	136	201.3	2.9
University of Southern California	43	116.4	5.1	42	185.2	5.0
Other institutions	85	155.4	3.4	80	199.8	3.7
Institution undecided	221	140.8	2.3	213	189.6	2.3

The two groups planning to enter the two divisions of the state university show no significant difference in ability, but marked differences are found between them and the students attracted by the leading private institutions of the state. Somewhat similar results are shown by an analysis of the sophomore groups which are

not reported here because the members involved are only one fourth as large and consequently the means are only half as reliable.

Summary

Over one-fifth of approximately five thousand men enrolled in the junior colleges of California who were included in the "California Junior College Mental-Educational Survey" were planning to enter some field of engineering. While the prospective engineers, on the average, are distinctly superior in ability and in achievement to the average junior college student, a disturbingly large percentage of individuals are decidedly inferior in ability and in preparation to the average of the entire group studied. Marked differences are found among the students planning on entering the different engineering fields. A large majority of the students had decided on an engineering vocation prior to their entrance to the junior college. Information as to ability, scholarship, pattern of high school preparation, time of occupational choice, and institutional preference has many implications for those engaged in guidance activities in colleges and high schools.

CONFERENCE ON ELECTRONICS AND ELECTRICAL COMMUNICATIONS *

GRADUATE WORK IN THE FIELD OF ELECTRICAL ENGINEERING

By EDWARD BENNETT

University of Wisconsin

1. The Distinctive Requirement of Graduate Work

In actual educational practice there is no sharp and definite plane of division between the activities of the periods classed as the graduate and the undergraduate periods of work. A sharp plane of division would imply that the methods and policies suited to the graduate side of the plane are actually unsuited to the situation on the undergraduate side, and vice versa: this, in turn, would imply striking differences in human nature in the two divisions.

The essential distinction between graduate and undergraduate work is this—in the graduate field, far greater emphasis is placed upon the acquirement of a profound and detailed understanding of a selected and somewhat limited field of study. This is in contrast to the acquirement of a more superficial knowledge of the wider field of the undergraduate studies.

In the four year undergraduate courses, the student develops his powers almost entirely in the regimented acquirement of the already organized knowledge spread out in the text-books. In the graduate field, much work of this type remains to be done; but the student is now expected to develop an increasing interest and skill in propounding and answering questions which are not to be found in the literature. As graduate work proceeds, in increasing proportion it becomes a somewhat independent individual investigation, or search, for relations, methods, processes, points of view, or useful combinations which are original contributions to knowledge.

The acquirement of the profound understanding of a limited field may be viewed both as an *end* in itself and as the *means toward an end*. From the point of view of the supporters of the schools, the *end* may be the contribution to knowledge which the student may be expected to make in acquiring the profound grasp of his subject. From the student's point of view, the *end* may be a satisfactory livelihood and a satisfying career in the particular graduate field he has cultivated. Viewed as a means toward an end, the

* Held at Cornell meeting S. P. E. E., June 19 & 20, 1934.

profound knowledge of the particular field is not an end in itself, but the *acquirement of the profound understanding* of the limited field of specialization is the only means by which the critical, analytical, and associative powers of the graduate student can be fully developed.

2. Selection and Preparation of Engineering Students For a Fifth Year

The greater emphasis on the acquirement of a profound and detailed understanding of a field is made possible to some extent by the greater maturity of the graduate students, but to an even greater extent by the adoption of scholastic requirements for admission to the graduate school which bring about a further selection from the already highly selected graduates of the four year courses. Expressed in terms of a rating scheme having ratings corresponding to *excellent, good, fair, poor,* and *fail,* it would seem that an undergraduate scholastic record well above the grade of *fair* should be required for admission to graduate status.

Opinions differ as to the provisions which should be made for a 5th year of engineering study. One proposal, which until recently has had few advocates, is the proposal to increase the length of the engineering course to 5 years for all students. The proposed 5 year courses generally contain a greater percentage of non-professional studies than the existing courses, particularly in the earlier years. To require all engineering students to remain on the campus for a fifth year, would seem to preclude the selective admission to graduate status which is possible under the existing 4 year courses.

Opinions and practices differ in the matter of the number of non-professional (liberal arts) studies which are to be required in the 4 year engineering courses. The movement seems to be to require an increased number of non-professional studies; this requires the deferment of some of the more advanced technical work from the fourth year of the undergraduate courses to the first year of graduate work.

3. Faculty Supervision and College Specialization

Paradoxically, graduate work, while characterized as *independent* individual work on the part of the student, costs far more per student to conduct than the undergraduate work. If the rich possibilities of the graduate relationship are to be realized, the *independent* work of the graduate student frequently makes an extremely heavy demand upon the master for deliberation and counsel. The burden is likely to be particularly heavy if the work of the student is in a field or on a problem not closely allied to the

field of the instructor. Teachers should exercise discretion in assuming responsibility for the direction of this type of graduate work since it is likely to detract from the teacher's effectiveness in his own field.

The undergraduate teaching loads are such in most electrical engineering departments that the departments cannot be expected to offer graduate work, particularly for the doctorate, except in a selected and relatively narrow section of the field of electrical engineering. Such a specialization in granduate work as between colleges is not an easy thing to bring about, but it warrants the serious consideration of each college, and of the Society for the Promotion of Engineering Education.

4. Subsidized Graduate Work

A considerable percentage of the graduate students enrolled in American universities are subsidized by awards, fellowships, or assistantships of the following types:

a. Fellowships which make no demands for service from the fellow;
b. Research fellowships, or assistantships, which require specified part-time services on assigned research or testing;
c. Teaching fellowships, or assistantships, which require part-time service in quiz or laboratory instruction.

There can be no objection to the subsidies of the first two types, but it is not so simple to arrive at a judgment about the teaching assistantship.

Viewed from the standpoint of the graduate student who is enabled to go forward with his graduate work by reason of the salary from his part-time teaching assistantship, the teaching assistantship is a beneficent arrangement.

Viewed from the standpoint of the same man who enters the teaching field after obtaining a doctorate and then contends for years with a meager salary because of the competition of part-time assistants, there is much to be said for more comprehensive child labor codes.

Viewed from the standpoint of a department head, or an administrator, desirous of building up the graduate enrollment, the teaching assistantship is a helpful expedient.

Viewed from the standpoint of a teacher in the graduate school attempting to build upon, or to reconstruct, the faulty foundation resulting from the instruction of the teaching assistant, it is a questionable practice.

Viewed from the standpoint of the student, or the parent of the student, who falls in the section of the immature half-time assistant, the practice is a vicious practice.

The practice can be viewed from other standpoints with conclusions equally conflicting. It is extremely difficult for the typical university faculty to review the situation and the results in an impartial manner, partly because so many members have carried on their graduate work with the aid of teaching assistantships. In view of the questionable and conflicting aspects of the practice, it would seem that in building up their graduate enrollments, the engineering colleges should guard against the subsidizing of graduate work by part-time teaching assistantships. A study of the results of the practice of awarding part-time teaching assistantships by the S. P. E. E. and a statement of the findings would be helpful, since the budgetary limitations which seem to require the continuance of the practice are not entirely imposed by legislative action. The limitations are in part set by educators who lack conviction as to the value to the commonwealth of a thorough, as contrasted with a shoddy, educational job, and hence lack the will to go after a small part of the community surplus now devoted to such wastes as advertising ballyhoo and the like.

THE RELATION OF THE COMMUNICATION FIELD TO THE ELECTRICAL ENGINEERING CURRICULUM

By M. P. WEINBACH

University of Missouri

Doctor Johann Kruger, Professor of Medicine at the famous University of Halle, Germany, in 1750, when asked by one of his students to express his views concerning the utilization of electricity, replied: "It is too early to venture any predictions, but the Germans have laid the foundation, the English will erect the building and the French will add the decorations. As to its use it seems certain that none will be found for it in theology; it is decidedly of no use in jurisprudence; where else could it be of any benefit but in Medicine?" It is more than probable that Doctor Kruger was not quite materialized, for the major applications of of electricity on the report of some experiments carried out by a Doctor Johann Winkler, Professor of Greek and Latin at the neighboring and equally famous University of Leipzig. In this report Doctor Winkler said that on discharging a Leyden jar through his body, he experienced convulsions from head to feet, violent agitation which threw his arms about and which forced blood from his nose. He further adds in his report that his wife, Frau Winkler, having the curiosity of a woman and particularly that of a professor's wife, repeated the experiment upon herself and as a conse-

quence was deprived for three days of the ability to walk, which was bad, and of the ability to talk, which was good. . . .

It seems that the prediction so interestingly told by Doctor Kruger was not quite materialized for the major applications of electricity are not in medicine. The epoch-making discoveries of Volta, Ampere, Oersted and Faraday have placed in the hands of the engineer the most powerful agent for the adaptation of the forces of nature to the service and comfort of man. In the hundred years following the great discovery of electromagnetic induction by Faraday, inventions and discoveries pertaining to the utilization of electricity succeeded one another with great rapidity. The telegraphic system of communication of Samuel Findley Morse, Wilde's generator, the telephonic system of communication of Alexander Graham Bell, Edison's incandescent lamp and his system of distribution, all contributed to the creation of what we call electrical engineering which revolutionized industrial methods, altered commercial relations, correlated social thought and improved living conditions throughout the world. In 1883, fifty years after Faraday's discovery of electromagnetic induction, we witness the establishment of the first organized courses in electrical engineering at the Massachusetts Institute of Technology and at the Institution in whose halls we meet today.

The material taught in the older branches of engineering, civil and mechanical, were pretty well established at the time electrical engineering made its appearance as a separate branch of the profession. Now and then we find some demand for addition to the subject matter taught and for minor changes in the sequence of organized courses in the curricula of civil and mechanical engineering. The case was quite different with electrical engineering. During the fifty years since the establishment of the first organized courses in electrical engineering to train men in the application of electromagnetic science, our knowledge of the natural laws pertaining to electricity and magnetism, of their relationship to each other, and of their application to arts and industry grew very rapidly. New applications were discovered daily; practice changed almost overnight; new theories were evolved and new laws were discovered and formulated. As a result of such a continuous and uninterrupted growth, of rapid and radical changes in the design, construction, performance and application of electrical machinery and apparatus, of the discovery of new relationships, and of the development of new theories, it was but natural that the material taught should also change, that new material be added from time to time and that the curriculum be reorganized and adjusted to conform to these newer theories and newer demands. It is significant to note, as illustrated by our present meeting, the reorganiza-

tion and adjustment of the electrical engineering curriculum is still going on, that material taught and relative amounts of time to be devoted to the specific courses offered are still subject to debate.

Thirty years ago there was a more or less marked disagreement among teachers of electrical engineering, among professional engineers, and also among practitioners and teachers, regarding what should be taught in preparing men to enter the field of electrical engineering. Some maintained that the course in electrical engineering should be strictly cultural with a lot of mathematical and physical sciences. Others took the attitude that in addition to mathematical and physical sciences, the course should be strictly practical and that the graduates in electrical engineering should be familiar with the design, performance, installation and testing of electrical machinery and allied apparatus. The large majority felt that the main object of a well balanced electrical engineering curriculum is to equip the student with a knowledge of the principles of electrical engineering in their relationship to allied sciences, with methods of attack and schemes of solution of problems more or less related to practice, so that the student should thus acquire in the degree commensurate with his personal aptitudes, the analytical ability and the mental discipline which are indispensable to the engineer in the exercise of his professional activities.

During the first twenty-five years of organized electrical engineering curricula at various institutions, that is during the period of development from a bare beginning to highly specialized applications, the demand for electrical engineering graduates was so great that irrespective of what form their training took, highly theoretical or highly practical, they were absorbed by the industries and the majority were successful and reached prominence.

It is generally conceded even by practitioners that the rapid development of electrical engineering in all its ramifications is due in a large measure to what is being taught in our engineering schools, how this material is taught and who is being taught. Judging then from past experience we may predict with impunity that irrespective of what form of adjustment our social and economic structure will experience in the future, the further progress in the application of electricity to the affairs and pleasures of man will depend to a greater or lesser extent upon what we teach, how we teach and whom we teach.

In the earlier organized curricula in electrical engineering about one-seventh or one-eighth of the semester-hours required for graduation was devoted to work in electrical engineering. The material consisted of the principles of electromagnetism as applied to the design and construction of direct current machinery, including schemes of predetermining their performance and of methods of

testing experimentally their behavior under load conditions. The curriculum included also courses in primary batteries and in storage batteries, in electro-deposition of metals, in telegraphy and in telephony.

The beginning of the century witnessed a radical reorganization of the electrical engineering curricula in our institutions. The courses in batteries and in metallurgy were more or less generally eliminated, and courses in alternating currents, transformers and alternating current machinery introduced. The polyphase system of transmission and distribution opened up a new line of investigations and applications, and with it came the synchronous motor and the induction motor, the central station and transmission line studies. These new developments in the application of alternating currents demanded higher mathematical analysis in the formulation of new theories and relationships, more refined methods in the predetermination of machine and line performance and more time to study and assimilate this material. As a consequence the few courses pertaining to telegraphy and telephony were gradually, though informally, eliminated from the required work and made elective or optional. The predominant cause for this, as just stated, was primarily the mass of new material pertaining to power machinery that had to be studied, investigated and experimented upon. Furthermore, teachers of electrical engineering were drawn mostly from those who had some practical contact with manufacturing industries or with power utilities which, in contrast with the communication interests, were greatly concerned from the beginning with what we teach in electrical engineering and how we teach it. They absorbed practically all our graduates and were ready at any time to advise us, to supply us with testing equipment at factory costs or even less, with technical literature and so on. For some time it appeared that the communcation interests had almost forgotten our existence.

During the decade before the war and during the war period the structure of the electrical engineering curricula at our various institutions consisted primarily of courses in power and power machinery, courses in central stations, in electric railways. Here and there we find an institution with an optional or elective course in telephony teaching obsolete equipment and details of practice long out of use.

While this rapid development and great activity was taking place in the power industry and with institutions of learning keeping step with it, the art of communications was also going through a period of great progress and development. New technical principles were applied to the conversion of sound waves into electrical waves, to improve the transmission of such waves along lines, to the

devising of schemes of distortionless transmission, to the design and construction of amplification methods, to radio telegraphy and radio telephony, to carrier currents for the simultaneous transmission of many messages and many other applications. Although we were more or less familiar with these developments in the art of communication, some of us were not quite certain that they constituted engineering problems.

This was the situation up to ten years ago when the American Telephone and Telegraph Company invited teachers of electrical engineering to an educational conference in New York City. This conference was called to inform educational institutions that the Bell System desired to coöperate with colleges in preparing men to enter the field of communications and that the company was ready to supply teachers of electrical engineering with technical material, with data and with testing equipment and apparatus by means of which to visualize, clarify and broaden the students' conception of electrical engineering theory and of its application to industry in general and to the art of communications in particular. Teachers of electrical engineering were impressed with the fact that, although through no fault of their own, they had neglected the educational value of communications material to illustrate the principles of electromagnetic theory and its applications.

This newly adopted policy of the American Telephone and Telegraph Company to coöperate with educational institutions was received with great enthusiasm. Practically all colleges that have an organized department of electrical engineering received as a perpetual loan from the American Telephone and Telegraph Company valuable equipment comprising oscillators, artificial lines, measuring instruments, bridges and other apparatus by means of which numerous principles of electromagnetic theory can be easily and effectively demonstrated. As you know, the equipment is excellently adapted to the experimental study of the behavior of circuits at different frequencies, to the study of such circuits when some property like the resistance or the inductance or the capacitance is adjustable. It may be used to demonstrate very effectively the phenomena of resonance not only in series circuits but also in parallel circuits in which the phenomena may be caused likewise by the adjustment of the circuit resistance. The equipment may be used to demonstrate effectively that in parallel circuits there may be two values of inductance or of capacitance or of frequency or even of resistance that may cause resonance, and that under certain well defined conditions such circuits may be resonant at all frequencies.

The artificial line is adapted, as you, know, to the experimental study of simple or recurrent symmetrical T and Pi networks and thus of circuits with distributed properties; to the study of the

space distribution of voltage and of current values in such circuits and thus to visualize transmission line behavior under any receiving-end conditions and for any frequency obtainable from the oscillator. The dependency of the electrical length of transmission lines upon the frequency of the supply, the concept of attenuation in voltage, in current or in energy values, and of the space phase-shift may also be easily and beautifully illustrated and thus wave propagation effectively demonstrated. These are but a few of the experimental studies in which this fine equipment may be used in our laboratories to illustrate numerous applications of electromagnetic theory and thus assist the student to assimilate it.

When this equipment was presented to us, we were immediately confronted with the problem of how and where to introduce this highly desirable material into our curriculum. Some, with the idea that this material is highly specialized communication engineering, felt that it should not be introduced in the undergraduate curriculum, and that if taught at all, it should be in graduate courses. Others felt that this material should be introduced in the undergraduate curriculum preferably in optional or elective courses. Some again were of the opinion that since this material is not only of a fundamental nature but illustrative of principles directly applicable to power circuits and to power transmission, it should be used for the benefit of our students whenever and wherever possible in the courses already listed in the undergraduate curriculum. There was at that time and apparently there still exists a feeling that the material included in the various courses listed in our curricula are all essential; that none of the subject matter could be eliminated, and that if any further material must be added to give more effective training to our students, it should be done by lengthening the period of training from a four to a five year course.

Let us see how this situation was met by our colleges. The requirements for graduation in electrical engineering have been investigated by the Board of Investigation and Coördination of our Society. We find in the report of this Board that the time devoted to required work in electrical engineering subjects differs considerably in the various institutions in the country. In two of the 76 institutions listed, the time devoted to electrical engineering subjects is slightly over 10 per cent of the total semester-hours required for graduation. In 18 institutions it is more than 10 and less than 20 per cent. In 42 institutions the time devoted to electrical engineering subjects is between 20 and 30 per cent, and in 14 it is between 30 and 35 per cent.

Of 23 institutions picked at random from the groups in which 10 to 30 per cent of the total time is devoted to electrical engineering five do not include this material in any form in their undergrad-

uate curriculum; eight offer a course in communications engineering as an undergraduate elective or as an option with some other course such as illumination; and 10 offer some of this material as a required 2 or 3-hour course under the name of communication engineering.

I regret that I did not have sufficient time to investigate more fully how and in what manner all of the 76 institutions embodied in their curricula the theoretical and experimental material mentioned above.

The Board of Investigation collected also opinions concerning the relative importance of the major divisions of the curriculum in electrical engineering, such as the sciences (physics, mathematics, chemistry), English, cultural subjects, shop work, modern languages, electrical engineering subjects and other engineering subjects. These were rated as of great importance, moderate importance, and of little importance. It was, obviously, beyond the scope of the investigating Board to collect opinions and to study the relative importance that should be assigned to the topic material included in the various required electrical engineering courses in the undergraduate curriculum. It may be worth our while and it is certainly within the province of a group such as this to investigate and study this matter.

It is frequently stated that our curriculum is overburdened, that the mass of material considered as fundamental in electrical engineering is too great to be effectively taught in a four-year course equivalent to 140 or 150 semester hours required for the undergraduate degree. Yet I find in the catalogs of 23 institutions the following topics mentioned specifically as part of undergraduate studies: primary and secondary batteries, a study of the National Electric Code, electric wiring, repair of instruments, transformer design and design of electrical machinery, power plant design, operation and management of electric stations, design and operation of electric railway systems, operation and management of public utilities, construction and operation of different types of telephone subscribers' stations, central office equipment, automatic and machine switching systems, toll telephone practice.

Would it not be worth our while to gather opinions concerning the relative importance of these and other topics in the undergraduate curriculum of electrical engineering? A committee charged to investigate, study and report on the relative importance of the subject content of our courses in electrical engineering would seem highly desirable at this time.

The topic assigned to me is "The Relation of the Communication Field to the Electrical Engineering Curriculum" I hope that I touched on it here and there in this paper, but I confess that it

is not quite clear to me what I was supposed to discuss. If by "Communication Field" here is meant details of practice, I would say emphatically that there is no place for it in the undergraduate curriculum. If by "Communication Field" on the other hand, is meant fundamental material at frequencies other than 25 and 60 cycles per second with illustrative applications from the field of communications, then some place should be found for it by all means.

The problem that confronts us is whether this material should be introduced in some of the fundamental courses already listed or whether one or more courses be specifically designed for it. As mentioned previously, many institutions offer a good deal of this material in one or more courses under the name of communication engineering. In some the work is required, in others, it is either elective or optional. Much of this material however, would fit in with a greater educational value in a course of alternating currents specifically organized to precede the usual courses in transformers, alternating current machinery and advanced courses in circuit analysis. The study of alternating-current circuit theory generalized for low and high frequencies with illustrative problems from both the power and the communication fields would unquestionably broaden the students' conception of the phenomena that take place. A study of circuits with adjustabe properties leading up to a more detailed discussion of resonant phenomena is of just as much value to a clearer understanding of the behavior of power circuits as it is of communication circuits. The T and Pi circuits are not used only in communication networks, they are used also in the solution of comparatively short power lines. Why not acquaint our students with the highly interesting and valuable properties of such circuits? Their study serves admirably as an introduction to the analysis and solution of filter circuits, of circuits with uniformly distributed properties such as the transmission line either for power or communication. In the study of such circuits we could effectively introduce the concepts of attenuation, space phase-shift, wave propagation and incidentally the exponential and the hyperpolic functions of real and complex variables, useful mathematical tools in circuit analysis and solution.

We devote a good deal of time and justifiably so to the study of power and instrument transformers, to induction regulators and constant-current transformers, and we neglect the study of audio and radio transformers or at best such studies are given in postgraduate courses. The fundamental theory is the same, and by pointing out the characteristic distinctions between them with regard to their design as determined by their particular uses, the

student will surely gain a clearer conception of their performance. It seems to me highly desirable that our work in transformers should also be generalized by teaching the theory and performance of transformers used in communications side by side with the power and instrument transformer.

We all agree that the theory of wave propagation at one frequency is essentially the same as for another frequency. The subject of transmission in its theoretical aspects could be therefore generalized with great benefit to the student. Furthermore, the study of the characteristic differences between the power and the communication line with regard to their typical performances will undoubtedly give the student a better idea of what is expected of one and of what is expected of the other. The power line is electrically short and the communication line is electrically long. In the power line transmission takes place in one direction only; the communication line on the other hand transmits intermittently in both directions. The sending-end voltage of a power line is constant and of a fixed frequency; that of the communication line is modulated by the subscriber and is thus varying and of many superimposed frequencies. The receiving-end impedance of a power line is adjusted in quantity and in reactive quality by and in accordance with the needs of the consumer; that of the communication line is fixed in value and in its reactive quality by the operating company.

In addition to the material mentioned above and which could be introduced in courses already listed in our curriculum, there are numerous other topics which, although of fundamental character, find their application more specifically in the communication field. The use of inductance, either uniformly distributed or in lumped form at definite points of a line, to balance more completely the effect of line capacitance and thus permit more or less distortionless propagation of waves within a specified frequency range, the effect of impedance irregularities along lines and the experimental location of irregularities and of faults, line impedance measurements by open and short-circuit receiving-end tests, reflection phenomena, measurement of transition losses in terms of bels and decibels, filter networks and other problems are of great educational value to the student in electrical engineering, and should find a place in the undergraduate curriculum.

Many of our students come with more or less indefinite ideas of radio, picked up here and there while playing at or with it. Quite a number choose electrical engineering because of their particular interest in radio which offered and might still offer good opportunities to our graduates. It would be desirable and quite proper to include in our undergraduate curriculum an elementary course

covering the principles of electromagnetic radiations, wave propagation through space, of thermionics, of rectification, amplification and reception circuits. Many colleges offer graduate work in radio engineering, but only a few consider it worth while to include some of this work in the undergraduate curriculum.

I have made an attempt to outline the desirability and the possibility of including fundamental material from the communication field in our undergraduate curriculum. That you agree with this, I am quite certain, for we all realize that we are not in a position to train specialists in any particular field of electrical engineering. I have also suggested that the inclusion of this material in our curriculum may be accomplished by generalizing our fundamental courses in electromagnetic theory particularly the courses in alternating-currents circuits, in transformers and in transmission line theory, and also by the inclusion of one or two required courses covering elementary work in wire and in radio communication circuit theory. This is precisely what we are doing at the University of Missouri with most wholesome results.

The feasibility of the suggested scheme is of course subject to debate. The individual interests of the teaching staff would have to be taken in consideration. It will require the revision of some of our courses. It will demand the elimination of what might be considered non-essential courses. What is and what is not essential could be determined only by a thorough survey and investigation of the topic content of our courses.

We are here to discuss these things and to exchange ideas that will help us to determine the type of training we should give to our students, so that they be better prepared to adapt themselves with equal facility to any field of electrical engineering.

SELECTION AND DEVELOPMENT OF TEACHERS FOR COMMUNICATION ENGINEERING INSTRUCTION

By O. W. ESHBACH

American Telephone and Telegraph Co.

The selection and development of teachers in the communications field differs from most general discussions applying to all engineering teachers only in so far as preparatory education and experience is involved. Just as there is no universally accepted best way of selecting employees, there is likewise no best way, that I know of, to select teachers or train them. Perhaps it is inherent that the things to be done may best be done in many different ways. Nevertheless, there are some obvious things which may well be con-

sidered as essential or fundamental to good procedure. Among them are:

1. Analyzing the job to be filled.
2. Knowing where to find good prospects.
3. Investigation of their past record of achievements.
4. Analysis of their personal qualities and ambitions.
5. Encouraging and helping them to take advantage of opportunities to obtain experience and continue professional study.

In reviewing what had happened to bring about the rising importance of instruction in science fundamental to communications, I could not help but feel that the objective of the instruction to be given was more important than it is ordinarily regarded, because it is a controlling factor in all of the elements of selection and training.

It was perhaps the same trend of thought which led Professor Weinbach to review the instances associated with the development of this instruction, for it is indeed in the past that we can identify some of the important changes and viewpoints which have brought us here to discuss the problems of our work. The element of confusion seems to characterize all history of progress. It has been present in the development of engineering education, just as it has been in the field in which we are interested.

So often in confused situations the best thing to do is to go ahead on the basis of experience and invariably the answer is found. Listening to Professor Weinbach's paper, it seemed to me that this was just about what was happening. Go back to the beginning of electrical science, if you will. It took centuries, from the time of the discovery of electricity and magnetism, before their relationship was quantitatively established. It took half a century from the discoveries of Faraday, Volta, and Ampere, before significant commercial inventions started a wide spread development in industry and an endless chain of further discovery, invention and commercialization. A significant thing in electrical engineering education was the urge to get at the foundation or understanding of underlying physical principles. Upon this, all of our progress has been based. Yet at stages, for want of better things to do, there were periods where practice, crude as it was, was overemphasized in education and not until suitable technical information appeared and men devoted their energy to study, research and teaching was there real leadership in our professional progress.

I think we might understand the desirable qualities of teachers if we go back just to the beginning of the twentieth century and trace the influence of men whom we all know and to whom we owe much. For even these were days when, for electrical engineering, the sign posts were down.

The development of instruction in communications and teaching personnel is not unlike that of engineering education in general. It so happened in the progress of science that the period just prior to the world war produced inventions which revealed a remarkable and fruitful outlet for the commercialization of many interesting discoveries.

While we may be reluctant to say so, the development of communications up to war time resulted largely from the application of brute force in contrast to the interesting and clever technical finesse that characterize its progress since then. Many here can remember the kinds of text books available on the subject of radio about 1914–18. While some of the instruction was necessarily crude, I do not think we need be ashamed of the things which were done in class and laboratory about that time, for teachers, stimulated by student interest, were trying to find out what to teach. Necessity in the war period created many things that changed the whole outlook of electrical engineering; and of no little significance was the bringing together of people interested in the quick solution of the tantalizing problem of communications. If a list of such men were compiled, it would include many of our foremost teachers and engineers and many of the younger generation now shouldering the responsibility of instruction in this phase of science. As a minor example within my own personal experience, a number of the people here in this room had the good fortune to meet during the war at College Park, Maryland. Among them are Dr. Guy Grantham, of Cornell, Dr. J. O. Perrine, American Telephone & Telegraph Company, Professors Dreese of Ohio State, Hartig of Minnesota, Canavaciol of Brooklyn P. I., etc. Connected with this same branch of Signal Corps training were also Professors Turner of Yale, Miller of Lehigh, Creese of the University of Maryland and General Rees through whose organization this war time activity was supervised.

When some of you become discouraged with the progress of your instruction in class and laboratory, or administrators with the availability of teachers, think back to this period, less than twenty years ago. If the United States government today were undertaking the same program of training, there are dozens of institutions any one of which would be better equipped by far, both in facilities and man power, than we were then. Progress has been made both in facilities and personnel, and these two are very much interdependent.

Professor Weinbach has very graciously ascribed no small part of the progress of the last ten years to the influence of the Bell System, and I should like to say that it is a source of satisfaction and justification of such efforts as we have made, to see the excellent

uses to which the Technical Journal and Quarterly are put, and to see how effectively you have taken such equipment as we were able to make available and develop your laboratory courses. From these things and publications of other firms have come the preparation of some very excellent books, and there is now in progress the preparation of a handbook of communications. The authors and editors of many of these books are here today. In the last few years circumstances have made available for distribution certain apparatus which will not be needed in the Telephone Company, but which is perfectly good for laboratory uses. For this we owe much to the Western Electric Company and the efforts of Mr. R. R. Weaver. It has helped and will help the development of your graduate and research work and in this way will unquestionably have a very large influence upon the development of the future teachers in the communications

While philosophical reflections on the past may give stable qualities of patience, tolerance and understanding, those responsible for an education preparatory to a life career must attempt to anticipate the requirements a decade or two ahead. I think this should be kept in mind particularly in the selection and training of teachers. You may think now that you are teaching communications, but actually what has happened is that circumstances have just opened up a field of application of electrical engineering that is destined to reach far beyond its most immediate center of interest. For this reason I would be inclined to discount somewhat the qualifications of practical experience preparatory to teaching, particularly operating experience, and emphasize more those personal qualities and mental attitudes so fundamental in the personality of teachers. Among them I would mention these as being of considerable importance: Scholarship, Trusteeship, Friendship and Kinship.

It is easy to identify certain obvious physical handicaps. It is more important and difficult to determine mental characteristics, for success depends primarily upon attitude and quality of mind.

Knowing the subject you are teaching is the first requirement. But no teacher can stop there. Unless he has that attitude of mind that characterizes him, as a student for life, he will soon slip behind the procession and cease to be a vitalizing influence in his environment.

Secondly, there is no more sacred trust to give to any person or group of people than the control of four years of the thinking of young men. It is a trusteeship, given not by parents alone but by society as a whole, which a teacher must recognize by cultivating an attitude which will willingly and knowingly accept the responsibility and the problems and satisfactions that go with it.

Akin to trusteeship is friendship. The attitude of aloofness and

self centered thinking has no place in the life of a teacher. Cordial, wholesome relations with students is the source of real stimulation, the most vital thing in education. I hope no person will teach or be permitted to who does not want to do so, or, as has already been said, regards teaching as secondary to his particular research.

I have added to these three one more which I have chosen to call kinship, meaning by that the feeling of belonging. A young teacher must feel he is a part of the family or department in which he is teaching, likewise, of the college or university. Teaching is the greatest of all professions. He should believe wholeheartedly in it and take pride in his associations.

I have always felt that in the selection of teachers evidences of these attitudes, such as are found in the records of their activities, achievements and interests, was a pretty good indication of likely success, and I would look for this type of individual among the graduate students in electrical engineering, physics and also mathematics. Frequently good prospects have been found in industry, but up to recent years the chances of interesting them has been rather discouraging, particularly because of the unfavorable comparison of probable financial rewards.

This, in brief, expresses my opinion on what I consider the most fundamental elements of selection as pertaining to teachers in communications. Their development justifies a broader and more philosophic discussion. I will merely call attention to a few well known facts so frequently overlooked.

While the direct responsibility for any personal development rests with the individual, it does not excuse older associates and department heads from taking a personal interest in bringing to fruition the hopes and ambitions of younger men, to the end that the department may work as an effective unit and in perpetual coöperation.

I think the most important elements in developing teachers, assuming the right individual has been selected, may be grouped under two broad classifications. The first is methods of imparting knowledge, or teaching technique; and the second, procuring information. The satisfaction of efficient performance and the confidence of knowing embody the essential elements of building a successful teaching career, but they are difficult of achievement without the interest and coöperation of associates.

I have often wondered what the reaction would be if a newly appointed instructor suggested replacing some of the furniture of our classrooms with tables and modern chairs, yet can we not fairly question even so simple a thing as the physical environment of the classroom? May anything worthwhile be learned from the conference technique so largely used in industrial training in recent

years? Are teachers in engineering aware of current developments in educational psychology? To what extent does an atmosphere of experiment exist in relation to teaching methods? These and many other questions may very reasonably be raised. I will merely leave them with you to think about.

Just recently, there appeared in the Reader's Digest an article by Dr. Phelps of Yale entitled "Six Famous Words." Those which he chose are the famous words of Hamlet, "To be or not to be." While there is no point of comparison with the situation under which it was uttered it does express the challenge in life for self expression. If these elements can be put into the life of young teachers deliberately by their older associates, a large measure of the responsibility for their development will be discharged. The article to which I referred went further by suggesting that to live intensely and richly is to widen the scope of our relationships. This philosophy which holds in its broadest application to life is likewise the answer to the challenge "to be or not to be" as related to a teaching career in higher education. Particularly, is it the key to knowledge and wisdom.

The means through which broadening of knowledge may be accomplished includes all opportunities for widening personal acquaintanceship and understanding of the principles and scope of current technical developments. Specifically it includes all group meetings or conferences of professional societies, bringing outside engineers into contact with students and faculty, summer employment in industry, profitably planned use of summer vacations and sabbatical leave for study, research, association with those engaged in consulting work, participation in the preparation of technical literature, and a practical scheme of exchange of teachers temporarily or permanently between institutions. While budget requirements often discourage efforts of this nature, too often opportunities are lost because of lack of alertness in recognizing possibilities or sensing the integrated values of cumulative experiences.

I have merely emphasized three main portals to a successful teaching career, the keys to which are the selection of the right individual, the development of effective teaching technique and the enhancement of knowledge and experience. The antithesis of this thought is an atmosphere lacking in perspective, in which the influence of self-selection and development, integrated with time, produces a self-centered and self-satisfied mediocrity.

APPLICATION OF COMMUNICATION TECHNIQUES TO OTHER FIELDS

By E. B. KURTZ

Head, Electrical Engineering Department State University of Iowa

I will first describe the application of Communication Techniques to the new and developing subject of Television. For many years electrical communication embraced the fields of telegraphy, telephony and radio. Courses have generally been taught in two of these subjects, namely, telephony and radio. If I view the field of electrical communication correctly from a teaching standpoint, I believe it is splitting up into telephony, radio, and television.

Now your first reaction will likely be that television is largely a duplication of radio. It would be more nearly correct to say that it is an extension of radio. To make this point clear I will outline an elective course (EE 108) in Television which we have taught for the last two years at the University of Iowa to senior electrical engineering students. The subdivisions in the order of presentation are as follows:

I. Image Structure,
II. Optics,
III. Photo-electricity,
IV. Amplifiers for Television Signals,
V. Television Systems,
VI. Synchronizing Devices,
VII. Transmitters for Television Systems,
VIII. Antennae for Television Systems.

Under "Image Structure" the number of picture elements for good viewing, persistence of vision, aperture distortion, and transmission band width are considered. Under "Optics" the fundamental physical laws are reviewed. Under "Photo-electricity" the different types of vacuum and gas photo-cells are discussed, and the color response, as well as dynamic response are considered. The effect of various types of circuits and loads upon the dynamic characteristic are also considered. Under "Amplifiers" advanced material on effects of inter-electrode capacities, stray wire capacities, etc., on frequency response are taken up. Studies of compensation, shielding from electro-static and electro-magnetic fields as well as shielding from mechanical vibration are also covered. Under Television Systems, the historical development, details of various mechanical systems such as the disc and mirror drum, details of cathode ray systems, etc., are considered. Part VI on Synchronizing Devices covers the problems involved in the use of synchroniz-

ing signals for the cathode ray systems. Part VII on Transmitters is an extended treatment covering the means employed to maintain a uniform frequency response over the extended range required in television. Under "Antennae" the various types are taken up, with special emphasis on types to be used to minimize ghosting effects, etc.

The course is accompanied by problems and design calculations, as well as by assignments to various posts during the regular Sound-Sight broadcasts from Television Station W9XK operated by the Electrical Engineering Department and Sound Transmitter WSUI of the University. In assisting on these broadcasts the students become familiar with the function and operation of the equipment as well as with the problems encountered with various types of program material.

I personally feel that the field of Television will likely be the outstanding application of Communication Techniques in the next decade, and that if any department is looking toward expansion of its communication courses, it will find this a most promising field. It is a most interesting field to study and contemplate, and it may logically follow, that if more engineers are caused to think upon television problems, the sooner the day will come when television will rise to the level of satisfactory performance. At the same time you will be completing, what I choose to call the electrical communication trinity, telephony, radio, and television.

Coming now to the application of Communication Techniques to other fields in which other than electrical students are interested, I wish to say that I have not had any experience so far with any formal courses directed particularly to such students. We have, however, had a considerable number of such students in our radio classes as visitors and we have played the part of consultant on many interesting applications.*

We have discussed the advisability of offering a service course to the people associated with research in which electrical equipment is employed. Our thought was to give it without credit, and only as an opportunity for these men to gain greater proficiency and understanding of the equipment involved. A 2 or 3 hour course with the first half devoted to vacuum tubes and circuits and the second half given over to the solution of special problems might be suitable as a practical helpful course.

* At this point the author showed about a dozen lantern slides illustrating various electronic applications in the fields of psychology, physical education, education, child welfare, music, speech, etc.

LABORATORY EQUIPMENT AND PRACTICE EMPLOYED IN TEACHING ELECTRONICS AND ELECTRICAL COMMUNICATION *

By HOBART H. NEWELL

Worcester Polytechnic Institute

The suggestion has been made that the viewpoint of widest interest in a discussion of laboratory equipment and practice used in teaching electronics and electrical communication might be that of the technical college primarily engaged in giving general electrical engineering training.

The Worcester Polytechnic Institute comes under this classification. Our choice of experimental work and equipment is an attempt to provide such laboratory contact with these subjects as may be of use to one engaged in any branch of electrical engineering. To insure a definite approach to the subject I wish to consider this choice, which is admittedly open to criticism and improvement at many points and hence likely to lead to discussion.

The undergraduate laboratory instruction is not made a separate entity but a part of the general laboratory courses. The work begins in the third year study of physical measurements with elementary experimental consideration of emission, space charge, and grid control in high vacuum tubes. Allied experiments are built around alternating current bridge measurements of circuit elements and electric waves on wires.

The equipment used here is of the simplest sort, direct current indicating instruments, control rheostats, a spark coil and neon glow tubes, simple oscillator, decade boxes, telephone receivers.

The next contact is provided during the second half year of the electrical engineering laboratory required for senior students. This has been preceded by a classroom course on electronics and is accompanied by further classroom study of applied electronics and communication circuits, not considered primarily as such, but as an extension of electrical circuit analysis.

The work has been varied from year to year, the following series of experiments comprising the latest effort.

1. Thermionic emission and space charge—high vacuum rectifiers and their circuits.
2. Phenomena of gas ionization—"Tungar" and mercury arc rectifiers.
3. Grid control of space charge effect—triode amplifier properties and circuits.

* Presented at the Communications Conference of the 42d Annual Meeting, S. P. E. E., at Ithaca, New York, June 19–23, 1934.

4. Grid control of gas ionization—"Thyratron" as a circuit control element.
5. Photoelectric phenomena—photocells as light control elements.
6. Analysis of network by alternating current bridge.

Each experiment is expected to require three hours of time in the laboratory, and an equal time in the preparation of a report. The sequence given is followed to insure the building up of a logical picture. A discussion of the equipment and practice followed in these experiments seems in order.

The equipment such as tube mountings, transformers, capacitors, etc., is, where feasible, provided as individual elements, neatly mounted to insure respect, but leaving the main circuit wiring to be carried out by the student. It is our belief that the expenditure of time required to do this is well worth while in view of the greater familiarity obtained with the circuits used. Commercially built equipment is available for inspection so that the student may recognize the device in practical form.

The power requirements are met by the normal laboratory alternating and direct current supplies.

The objectives in the first experiment of this series are to bring out more fully the conditions controlling the flow of electrons through a vacuous space, the commercial utilization of this action, and effects of non-sinusoidal currents on instrument indications.

Data are taken using direct current meters to permit plotting families of curves showing limitation of current flow by emission and space charge. Half and full wave rectifier circuits are set up with and without filtering and loads. Both effective and averaging types of instruments are used in pairs in the output circuits of the rectifiers so that differences in their indications can be accounted for by known wave shapes, and used to analyze unknown ones. The low power used emphasizes the effect of the power used by instruments.

A most satisfactory experiment from our point of view is the attempt to obtain current voltage relations for the tungar tube when using a low resistance anode circuit. Practically all students, in spite of classroom efforts, expect a smooth curve as for the high vacuum tube, and are brought to an instructive halt by the tripping of the circuit breaker. The voltages present between electrodes of the mercury arc are used to set up another problem in distorted wave circuits.

The recently developed cathode ray tubes of high brilliance and low cost will undoubtedly be of great assistance in this field of study. We have made some use of these but feel that a sweep circuit of sufficient simplicity and low cost to permit its use in

numbers by untrained students has not been available. A recent offering by one of the manufacturers appears to approach the solution to this difficulty.

It is my feeling that an oscillograph should ultimately result that can be used by the student with the same nonchalance and freedom from overpowering interest shown a voltmeter. Moving conductor instruments cannot be satisfactorily used, at least in our case, because of the power required to operate them.

The conventional curves for the triode are obtained in some detail and used to compute the tube factors. The tube is then inserted in a single stage amplifier, the gain measured, nad compared with the predictions based on the tube data obtained.

The student is here experimentally introduced to the problems, common in communication circuits, of measurement of small power at audio frequencies, and to consideration of the transformer as an impedance changing device.

The "Thyratron" is studied from the point of view of a combination of the effects observed in the "Tungar" and triode experiments, noting the effects of increased current possibilities and differences in the control action.

The use of the cathode ray oscillograph in showing the wave forms present proved confusing to many students because it showed too much. The smooth portions of sine waves looked for were complicated by unexpected oscillations. It seems that from an instructional point of view a less sensitive oscillograph might tell lies but be believed.

The present status of the photoelectric experiment is the least satisfactory of the group. Several of our staff members have planned the experiment in different ways, but this year we have simply used a photocell-amplifier and a photronic cell as illumination meters, with screens to show color effects. A more basic plan is desired but we have not arrived at it as yet.

The alternating current bridge is used at two frequencies to find the equivalent *T* and Pi for an unknown network. A commericial "Universal" bridge is used, fed by a vacuum tube oscillator. The students experience difficulty both in manipulation and in interpretation of the results obtained.

The causes for this trouble are perhaps not hard to find. The bridge method is here used after a long period of "power house" type of measurements, during which the idea of impedance as a ratio of indicating instrument readings has taken firm hold. It is evident that our laboratory course has need for a look at circuit constants from a different angle at this stage.

The organization of the graduate laboratory work in communication, or in our case perhaps better termed communication aspects

of electrical engineering, proceeds along somewhat different lines. Here there is no set division of time between classroom and laboratory. The classroom study proceeds until laboratory confirmation is desirable. Activity is then transferred to the laboratory until a satisfactory conclusion has been reached.

The first half year is devoted to a study of repeated networks and long lines, treated as an extension, from the communication engineers point of view, of the undergraduate work on alternating current circuits and power transmission.

Experimental data are obtained and analyzed for equalizer, filter and artificial line networks, using a beat frequency oscillator as a power source, and making measurements mainly by the impedance bridge and oxide rectifier type indicating meters.

We are making an increasing use of these instruments in place of vacuum tube devices for current and voltage measuremnts. Admittedly the power consumed, particularly for the ammeters, must frequently be taken into account. Our primary interest is not, however in the precision but in the simplicity of the apparatus so that attention may be concentrated on the phenomena under observation.

Loading coils, of types obsolete for telephone use and inexpensively obtained, have been found most useful in the setting up of predictable networks because of their uniformity and low power factor.

The work of the second half year proceeds along the same plan and concerns itself with radio frequency circuits and transmission.

The first laboratory project is the setting up of a small modulated high frequency oscillator. The resulting carrier is observed with the cathode ray tube and conditions found giving modulation of various depths. This is followed by measurement of the properties of an antenna, using conventional substitution methods.

The inclusion of experimental work on the measurement of radiated field intensities may be a bit unusual and perhaps instigated by the writer's interest in the subject. A trial has led to the belief that such experience, even if limited, helps greatly to build up a real picture of radio transmission.

No tests were made this year on the receiving end of the radio channel, on the premise that this equipment should be more familiar to the men. Apparently there has been much looking without sight so that something of this kind should be included.

Fortunately for the laboratory budget it appears that apparatus of moderate precision serves us very well for these measurements where only a general picture is needed. A group consisting of a small calibrated condenser, decade box, thermogalvanometer, cathode ray tube, an unshielded oscillator provides for most requirements.

The field intensity measuring set used by the writer was free for student use this year, but very passable work has been carried out using a modified "Radiola 28" receiver and a home-made generator.

It is admitted that a commercially built signal generator properly shielded and covering a wide frequency range should be available for general use. These are, however, expensive items where specialized study is not made.

Telegraph, telephone and radio plants are visited by undergraduates on other than laboratory time, but for graduates inspection trips are conducted as a part of the laboratory instruction. There are fortunately available within easy reach two regional stations with radically different equipment, one having a directive antenna, a high power synchronized broadcast transmitter, and a short wave intallation of moderate power. The interest taken by the students in these trips, and the apparent profit obtained were most gratifying.

The desire to conduct individual experiments finds an outlet in most cases through the activities of a radio club. There are occasional students who attempt more pretentious work usually having as its object the presentation of a student paper before the A. I. E. E. student meetings. This is given all possible encouragement, particularly in combination with graduate theses.

In the conduct of the laboratory an effort has been made to create the feeling that we are not at this time primarily interested in electronics or communication as such, but as an aspect of the general field of electrical engineering.

We are concerned with electrons when freed from some of the restraints met in conductors, and with electric fields freed from wires. Our methods of measurement change when we encounter higher frequencies and lower powers, and our circuits soon become electrically long. The building up of a concrete picture of these things, by physical contact, is the end in view.

A GENERAL ENGINEERING COURSE

By E. A. HOLBROOK, *Dean*

Beginning in September, 1935, the School of Engineering at the University of Pittsburgh will offer a new four year curriculum in General Engineering, leading to the degree of Bachelor of Science in Engineering.

The heads of the several professional departments of the School of Engineering, in their report to the Chancellor of the University asking approval of the course, made the following statement:

"We believe that a four year under graduate course combining engineering fundamental subjects and methods, with a wide selection of electives, offers one way to a broad undergraduate university training. The course here proposed gives the student the present fixed engineering curriculum for the freshman year. In the second year he is allowed eight hours of free electives; in the third year, eleven hours; and in the fourth year, eleven hours. The subjects he studies in the School of Engineering are all general in nature, as for example, drawing, surveying, mechanics, hydraulics, and the more general courses in Electrical Engineering and in power. He is given some insight into management and the mineral industries. He is required to take the regular English, mathematics, chemistry, physics and mechanics of the engineering courses. However, he is not required to take the usual specialized design and applied engineering subjects during his third and fourth years. In brief, the proposed course is our notion of a college training that will fit a man to live well in the world of 1935."

The School of Law and the School of Medicine at the University of Pittsburgh have indicated that this course, including appropriate elective selection, is a satisfactory, pre-legal or pre-medical course in preparation for the respective schools. However, we are most concerned with the course as offering a more liberal engineering curriculum and a more rigid and conservative general educational curriculum.

The details of the course are as follows:

The free electives for the four years total 30 credit hours; of these, a student may elect not to exceed 20 credit hours of courses in History, Philosophy, the Political and Social Sciences, Psychology, Accounting, English, and the languages. He may elect 10 or more credit hours in Chemistry, Physics, Mathematics, Geology, Zoology or other sciences or studies in any department of the Schools of Engineering and Mines.

SUMMARY OF CREDIT HOURS

School	Freshmen	Soph.	Jr.	Sr.	Electives	Total
Engineering	5	11	22	2	10+	50+
College	25	16	0	4	20+	65+
Business Administration	0	0	0	14		14
Mines	0	0	2	4		6
	30	27	24	24	30	135

FIELDS OF STUDY REQUIRED (IN CREDIT HOURS)

English	Math.	Chem.	Physics	Drawing	Psychology	Phys. Ed. or ROTC
10	16	8	8	4	1	2

Civil Eng.	Elect. Eng.	Mech. Eng.	Industrial Eng. & Management	Mining & Metallg.
11	9	10	6	6

Economics	Commerce & Industry	Liberal Arts Electives	Science Electives	Total
6	8	20−	10+	135

Of special note is the fact that there are in the proposed course no highly specialized engineering or mines courses. The student takes in the Civil Engineering field, short courses in drawing, surveying, mechanics, and hydraulics. In Mechanical Engineering he has courses involving Engineering Mechanics, Elementary design of machines, and steam and gas engines and general power courses. In the Industrial Engineering courses he studies the functioning of the modern business organization; while in Metallurgy and Mining, he learns about the production and use of our minerals and metals. In general the student receives a breadth of engineering, without intensive application to any special field.

SPECIALIZATION AND ITS PLACE IN UNDERGRADUATE CURRICULA

By C. W. DUNHAM

Assistant Engineer, Port of New York Authority

As a member of the Society for the Promotion of Engineering Education I have been very much interested in some of the articles appearing in the JOURNAL and relating to the problem of training young men for the engineering profession. The article by Mr. Wm. G. Grove in the issue of February, 1935, reveals the thoughts of a practical engineer upon one particular subject for Civil Engineering students.

The following comments are not intended to be a refutation of Mr. Grove's ideas but are an attempt to give, in a friendly manner, the results of my own experiences and thoughts on this subject. Naturally, each one of us is the product of our God-given abilities developed and modified by the impacts of the hosts of influences which have surrounded our lives. In many cases the practical engineer and the professional educator have very different ideas about the training of young men. Having been a teacher in Civil Engineering at Rensselaer Polytechnic Institute, a member of the engineering staff of the Bethlehem Steel Company and a member of the Design Division of The Port of New York Authority, I believe that I may be classed as one of those familiar with both viewpoints—that is, neither solely a teacher nor exclusively a practical engineer. I shall therefore offer a few suggestions in the belief that they are moderately impartial.

In the first place, my own experience together with my contacts with young engineers shows that certain qualities are very desirable in the field of practical engineering. It is generally easy to find someone to solve a problem in theoretical analysis when that problem is outlined to him. However, it is sometimes difficult to find a man who can anticipate, recognize and outline that problem. In short, the weakness appears to be the result of lack of experience, thought, appreciation, initiative, inventive power and ability to back away from the details of a problem enought to see it as a whole. Furthermore, coöperation with those around him is very essential before a young engineer can be in a position to exert leadership. These qualities are not things which can be taught specifically. Their development, as far as the college can accom-

plish it, must come indirectly through the spirit of the institution, the individuality of the work required from the student and the example and character of the faculty. As a homely illustration I might say that every young civil engineer knows that $M = EI \times d^2y/dx^2$ but few of them know what in the world to do about it.

In the second place, what is the situation of the educator? He is presented with a crop of young men, mostly high school graduates of the previous spring. They are young and inexperienced. Many have chosen their particular course and college because of the direct or indirect influence of someone whom they knew and admired. Others have had little or no choice in the matter and their ideas are not settled in their own minds; in fact, they can not be expected to be settled. Gradually the choice of their profession tends to crystallize in their minds but, even in their junior and senior years, they are by no means able to decide their own future.

We all know that, regardless of our plans and choices upon entering or leaving college, our life work is the result of the opportunities available to us and the forces exerted upon us. These cannot be foreseen.

The engineering educator also has, in general, only four seemingly short years in which to prepare these young men for the economic battle of life. He is not justified in deciding what their work shall be. If he tries to have his students specialize too much in any particular thing he is thereby tending to handicap them in accepting and meeting other opportunities in life.

I believe that the present curricula of most engineering schools are broad enough to give the student a fair foundation in the main divisions of engineering work. It should be so. Each pupil should learn the fundamentals of other branches of engineering as well as that one under which he is registered. I am afraid that the tendency is to overload him so badly that it is a continuous struggle on his part to make the grade. I wonder if he ever gets the time to appreciate what it is all about. Work ought not to be so concentrated that he does not realize the value and importance of engineering truth, engineering thinking, engineering progress and also human relationships. As far as is possible, the effort of the college should be the development of character, reasoning power and good judgment.

I myself have been fortunate enough to have been able to follow civil engineering work. However, I must admit that I do not have the time, physical strength and mental capacity to keep up with all developments of the various branches of work which come under that one general heading. In our life work we specialize by necessity. But what of the undergraduate student? How can we ex-

peet him to acquire more than a thorough foundation in engineering education? What right have we to force him to specialize?

In conclusion, I suggest that the purpose behind any revision of the curriculum of an engineering college should be that of securing the best possible soundness, balance and practicality. It should not be overloaded but should be such as to teach the student a love of work, particularly that of engineering. Leave the specialization for post-graduate courses or the school of practical experience. For instance, the ideal training for a designer is first a broad education, then work in the practical construction industry and finally specialization in his chosen field.

Above all, whether we are teachers or practical engineers, let us love and honor our chosen profession and we shall instill that same feeling in the minds of the young men around us.

LETTER TO THE EDITOR

The writer makes bold to call to the attention of instructors in engineering two cardinal points that he thinks should be impressed upon the minds of students.

At the very beginning of the study of a topic the student should ask, "What is it all about?" Having a clear idea of the objective from the start, the steps leading to it can be followed much easier than by many wanderings, often in the dark. A large percentage of those that "fear the Calculus as children fear the dark" would not do so if at the outset they found out what it is all about. What is mass? To many an engineer and student, "Mass is a coefficient which it is convenient to introduce into calculations." The writer recalls his college days of more than fifty years ago. He received high marks in Descriptive Geometry. Yet if he had met a warped surface on the street he would not have recognized it without an introduction. Was not the instructor partly to blame?

L. Bolton, whose essay, "Relativity," was judged the winner of the Eugene Higgins prize of $5,000 for the best popular essay on the Einstein theories, later enlarged his essay into a book. In the preface he mentions that he found the general drift of the subject harder to grasp than the details of the advanced mathematical work. The great question he says is, "What is it all about?" "I can tell you what it is *about,* although I can not tell you what it *is,*" writes E. E. Slosson in the prefatorial dialogue of his "Easy Lessons in Einstein."

The second point that I would emphasize is that a simple solution of a problem should be sought. Of course, a simple solution can not always be found, yet it is worth the endeavor. Every engineering student would do well to read Poe's "The Purloined Letter." An entire building had been searched without avail by skilled detectives for a stolen letter. Yet the letter, much soiled and crumpled, nearly torn in two, was all the time exposed to full view in a card rack that hung dangling by a dirty blue ribbon from a brass knob just beneath the middle of the mantelpiece.

Many instances can be cited where a simple solution has been found for a seemingly difficult problem. A striking illustration is the Lorentz Transformation equations used by Einstein as groundwork in developing his theories. These equations explained the results obtained by the famous Michelson-Morley Experiment

that so long baffled physicists. The mathematics of Einstein are far beyond the comprehension of an ordinary mind but to understand the Lorentz equations only a knowledge of elementary algebra and geometry is required. Einstein himself writes, "General laws of nature are co-variant with Lorentz transformations."

ROBINS FLEMING

AMERICAN BRIDGE CO.,
NEW YORK, N. Y.,
February 20, 1935

LETTER TO TEACHERS OF MANAGEMENT

To Teachers of Management:

In the United States we have not only abundant natural resources, but man-power, equipment and wealth sufficient to produce enough for everybody; and, not in spite of, but very largely because of these very facts, we all have to suffer the ills of the present economic depression. Could anything except the grossest mismanagement produce a situation so absurd? In former times an economic depression was like a stage-coach that had stuck in a bad place in the road. The passengers got out and put their shoulders to the wheels; and, after the thing got going, they brushed off their clothes, got back aboard and things went very much the same as before. Society under the present depression is more like an automobile that has tried to climb a telephone pole. After waiting two and one-half years for the thing to get back onto the road of its own accord, we called the wrecking truck and are now in tow with the motor giving an occasional cough, while we earnestly hope that it will shortly take hold and enable us to run under our own power, before the bill for towage gets bigger than we can pay. The next major depression is very likely to resemble an airplane crash.

Meanwhile, during the fifty years since Frederick W. Taylor began his work, we engineers have developed in management a body of theory and practice which has proved itself in application, as far as industry is concerned. Methods, of course, are of local and temporary applicability; but engineers who have dug beneath the methods which constitute the surface of improved management, have found beneath a body of principles which—until the contrary is proved by trial—we are justified in believing to be perfectly general in their applicability. Since the beginning of the movement for improved management the experience of engineers has been that merely local application of the principles of management in time reaches a point beyond which it is ineffective unless reenforced by the application of the same principles to adjacent areas.

The present depression shows how little even the best management of even the largest corporation can withstand general social-economic conditions. That is; we have again reached the point, already familiar to industrial engineers, at which the method of further progress is to apply the principles of management to a wider area, in this case society in general.

At this point we should remember that it has taken fifty years to make such progress as we have made in industrial management. This experience should make us realize that the improvement of social-economic management will be a work of many years. It will therefore devolve very largely upon the students whom we now have, and whom we shall have during the rest of our lives, to accomplish this task. I beg leave to submit to my fellow teachers of management, that we owe it to these young men and to society, to give them an appreciation of the task before them. I believe in laying this matter before them as primarily an opportunity for public service; but it may be well also to let them know how badly engineers have been hit by this depression and that the way for these young men to avoid, or at least mitigate, a similar disaster to their own generation is by giving the world better social-economic management.

I beg to submit also that this task is fundamentally a continuation and extension of the work which engineers have been doing during the last fifty years in the improvement of industrial management. New methods will have to be developed to suit the new conditions, but the underlying principles remain the same. There will be need, however, at least in the near future, to stress the ethical principles, Ideals, Fair Deal, Discipline and Efficiency Reward, which Harrington Emerson so courageously preached and practiced.

I do not doubt that social-economic management will be improved, because I can not believe that intelligent people will tolerate the periodic recurrence of such disasters as the present depression; therefore I do not expect engineers to be alone in the work. In fact engineers alone would not be likely to succeed, because social progress of any sort must be motivated by an appeal to emotion; and we are generally, both by temperament and education, unfitted to make such an appeal. However, the work will go very much better if engineers make a full contribution of their professional knowledge and methods.

Management engineers especially have had an experience in industry which will be of inestimable value in improving social-economic management. Take, for example, the matter of a planned economic order. On the one hand, our experience of the benefits which the individual business has derived from planning causes us confidently to expect that planning will produce similar benefits in social-economic management. On the other hand the same experience causes us to realize that we can not rush headlong into planning, but must develop it step by step with the application of the other principles of management. We remember too, that engineers at first tried to centralize industrial planning, and that they

were obliged to change their methods and decentralize, in other words, to leave to superintendents, foremen and workmen enough discretion to enable them to deal with local conditions. It will be up to engineers to keep social-economic planners from repeating our old mistakes.

In the application of every other one of the principles of management, the services of engineers of the coming generations will be greatly needed. It is and will be our duty and our privilege to prepare them for their task. I deliberately refrain from detailed suggestions as to how that is to be done, because I think that each of you will prefer, for the present, to work out his own methods; but, if you accept the main idea, the time will soon come when the work will be greatly accelerated by an exchange of thought and experience among us.

GEORGE H. SHEPARD,
Professor of Industrial Engineering
and Management, Purdue University.

NEW MEMBERS

ARMSTRONG, CECIL W., Instructor in Mechanical Engineering, University of Kansas, Lawrence, Kans. E. D. Hay, D. C. Jackson, Jr.

AUSTIN, WARD H., Instructor in Engineering, Marin Junior College, Ross, Calif. C. E. Cherry, Franklin O. Rose.

BARKER, GEORGE J., Assistant Professor of Mining and Metallurgy, University of Wisconsin, Madison, Wis. B. G. Elliott, G. L. Larson.

BEHRENS, ROBERT G., Sales Manager, College Dept., Associated Technical Publications, 9009 Loomis St., Chicago, Ill. C. C. Williams, E. S. Ault.

BIBB, SAMUEL F., Assistant Professor of Mathematics, Armour Institute of Technology, Chicago, Ill. J. B. Finnegan, H. T. Heald.

BUSH, B. H., Associate Dean of Engineering, Fenn College, Cleveland, Ohio. M. E. Nichols, Samuel Ward.

CARPENTER, ARTHUR H., Associate Professor of Metallurgy, Armour Institute of Technology, Chicago, Ill. J. B. Finnegan, J. C. Peebles.

CHAMBERLAIN, STEPHEN J., Instructor in Engineering Drawing, Junior College, Burlington, Iowa. A. H. Fuller, R. A. Caughey.

COOPER, LINTON L., Professor of Mechanical Drawing, Louisiana State University, Baton Rouge, La. L. J. Lasselle, D. S. Anderson.

COX, GLEN N., Associate Professor of Mechanics and Hydraulics, Louisiana State University, Baton Rouge, La. L. J. Lasselle, D. S. Anderson.

CRAFT, BENJAMIN C., Assistant Professor of Petroleum Engineering, Louisiana State University, Baton Rouge, La. L. J. Lasselle, D. S. Anderson.

DENT, JOSEPH B., Assistant Professor of Engineering Drawing, A. & M. College of Texas, College Station, Texas. A. Mitchell, V. M. Faires.

DIXON, DON P., Instructor in Mechanical Drawing, Louisiana State University, Baton Rouge, La. L. J. Lasselle, D. S. Anderson.

DORAN, EDWIN B., Professor of Agricultural Engineering, Louisiana State University, Baton Rouge, La. L. J. Lasselle, D. S. Anderson.

DUTTON, HENRY P., Professor and Acting Chairman, Dept. of Social Science, Armour Institute of Technology, Chicago, Ill. J. B. Finnegan, H. T. Heald.

ENSZ, HERBERT, Associate Professor of Civil Engineering, Armour Institute of Technology, Chicago, Ill. H. T. Heald, J. B. Finnegan.

FASSETT, FREDERICK G., JR., Assistant Professor of English and History, Massachusetts Institute of Technology, Cambridge, Mass. Vannevar Bush, Henry L. Seaver.

FENN, FRED H., Instructor in Engineering Mechanics, Louisiana State University, Baton Rouge, La. L. J. Lasselle, D. S. Anderson.

FRAIM, JOHN P., JR., Supervisor of Aeronautics, Louisiana State University, Baton Rouge, La. L. J. Lasselle, D. S. Anderson.

FULGHUM, WALTER B., JR., Instructor in English, Armour Institute of Technology, Chicago, Ill. J. B. Finnegan, Walter Hendricks.

GILLILAND, WILLIAM L., Assistant Professor of Chemistry, University of Maine, Orono, Me. C. A. Brautlecht, L. C. Jenness.

JOHNS, WILLIAMS B., JR., Associate Professor of Mechanics, Georgia School of Technology, Atlanta, Ga. A. D. Holland, R. A. Trotter.

JOHNSON, HAMILTON, Professor of Mechanical Engineering, Louisiana State University, Baton Rouge, La. L. J. Lasselle, D. S. Anderson.

KELLY, WILLIAM E., Registrar, Armour Institute of Technology, Chicago, Ill. J. B. Finnegan, H. T. Heald.

LASSALLE, LEO J., Professor of Engineering Mechanics, Dean, College of Engineering, Louisiana State University, Baton Rouge, La. R. A. Seaton, L. E. Conrad.

LLOYD, STEWART J., Professor of Chemistry, University of Alabama, University, Ala. Geo. J. Davis, John M. Gallalee.

MATHEWSON, JOHN H., Assistant Professor Mathematics and Engineering Drawing, University of Toledo, Toledo, O. W. S. Smith, I. F. Zarobsky.

MATTHES, GEORGE F., Assistant Professor of Electrical Engineering, Louisiana State University, Baton Rouge, La. L. J. Lasselle, D. S. Anderson.

MCCORMACK, HARRY, Professor and Director, Department of Chemical Engineering, Armour Institute of Technology, Chicago, Ill. J. J. Schommer, J. B. Finnegan.

MITCHELL, ULYSSES G., Professor and Chairman, Department of Mathematics, University of Kansas, Lawrence, Kans. D. C. Jackson, Jr., E. D. Hay.

OESTERLE, JOSEPH F., Assistant Professor of Metallurgy, University of Wisconsin, Madison, Wis. Ben G. Elliott, G. L. Larson.

OLSON, CLAIR C., Instructor in English, Armour Institute of Technology, Chicago, Ill. J. B. Finnegan, Walter Hendricks.

PEGUES, BOYKIN W., Professor of Civil Engineering, Louisiana State University, Baton Rouge, La. L. J. Lasselle, D. S. Anderson.

PILLET, FREDERICK F., Associate Professor of Civil Engineering, Louisiana State University, Baton Rouge, La. L. J. Lasselle, D. S. Anderson.

PORTER, R. CLAY, Instructor in Mechanical Engineering, University of Kentucky, Lexington, Ky. W. B. Wendt, Lester S. O'Bannon.

ROGERS, FRED A., Dean of Engineering, Professor of Electrical Engineering, Lewis Institute, Chicago, Ill. H. H. Higbie, J. Raleigh Nelson.

SWINEFORD, CHARLES R., Associate Professor of Mechanical Engineering, Armour Institute of Technology, Chicago, Ill. H. T. Heald, Stanton E. Winston.

THOMPSON, JAMES S., Professor of Physics, Armour Institute of Technology, Chicago, Ill. H. T. Heald, R. V. Parry.

TIBBALS, C. AUSTIN, Professor of Chemistry, Armour Institute of Technology, Chicago, Ill. J. B. Finnegan, J. J. Schommer.

TOPPING, CHARLES H., Assistant Professor of Mechanical Engineering, Clemson Agricultural College, Clemson, S. C. D. D. Curtis, S. B. Earle.

VOORHIES, M. B., Professor of Electrical Engineering, Louisiana State University, Baton Rouge, La. L. J. Lasselle, D. S. Anderson.

WEBER, HOMER S., Associate Professor of Engineering Drawing and Mechanics, Georgia School of Technology, Atlanta, Ga. A. D. Holland, R. A. Trotter.

The T-SQUARE PAGE

DEVOTED TO THE INTERESTS OF THE DIVISION OF ENGINEERING DRAWING

FREDERIC G. HIGBEE, EDITOR

Lettering: Recently a comment was made by a personnel officer of a governmental division now recruiting a large staff of engineers, that he had been searching in vain through an enormous stock of applications for a draftsman who could letter well. Teachers of engineering drawing frequently hear comments of similar character made by teachers of advanced engineering subjects, or at least caustic (usually) remarks about the character of the lettering appearing on drawings made in upper class courses.

In the privacy of their own conferences, engineering drawing teachers are inclined to worry about lettering and to admit frankly discouragement over the quality of the lettering they are able to get from engineering freshmen. Form, proportion, composition are all universally taught; a reasonable amount of practice time is allowed in drawing courses; criticism of a constructive and continuous character is freely offered, yet drawing teachers are far from satisfied with the lettering which results.

There are some elements in this problem sometimes overlooked. For example: (*a*) How far would a teacher of English get if he had to spend a goodly portion of his allotted time teaching penmanship? (*b*) Even after considerable practice, not all golfers shoot the course in par. (*c*) Nothing in engineering literature, or in engineering payrolls, indicates that the profession of engineering considers lettering, or even drafting, an important end worthy of the serious and painstaking effort required for perfection. (*d*) Is there much evidence on commercial drawings that good lettering is important? (*e*) Do engineering societies or engineering departments, or commercial concerns, consistently refuse to consider drawings because of unsatisfactory lettering?

Specifications, and adherence to specified standards, might be worth considering.

NECROLOGY

JOHN MILTON FOSTER, Associate Professor of Aeronautical Engineering at North Carolina State College, died in Raleigh on February 14, 1935, at the age of 46.

Professor Foster was born in Richmond, Kentucky, on May 20, 1888, the son of John Milton and Elizabeth Foster. After a secondary schooling in his native city he attended the University of Kentucky and received the degree of Bachelor of Mechanical Engineering in 1911. This institution also conferred upon him the degree of Mechanical Engineer in 1923.

After graduation from the University in 1911, Professor Foster entered the special apprentice course of the Allis-Chalmers Company in Milwaukee, Wisconsin, and was employed for some time in the various departments of this plant. Later he went to Nashville, Tennessee, where he took a high school position as teacher of industrial arts. In 1918 he came to Raleigh as Assistant Professor of Mechanical Engineering at North Carolina State College, and was later promoted to the grade of Associate Professor; more recently he was specially designated to fill the position which he held at the time of his death.

Professor Foster was one of the pioneer aeronautical instructors of the Southeast, having served as a licensed ground school instructor for the Curtiss-Wright Flying Service in Raleigh prior to the development of aeronautical courses at North Carolina State College. At the College he was in charge of the Aeronautical Option in the Department of Mechanical Engineering from the time of its inception in 1929. He did considerable flying although he was not a licensed pilot.

Professor Foster was well known in engineering circles throughout the Southeast. In addition to his affiliation with the Society for the Promotion of Engineering Education, he held membership in the American Society of Mechanical Engineers, the North Carolina Society of Engineers, the Raleigh Engineers Club, and the Aeronautical Chamber of Commerce of America. He was also a member of the Alpha Tau Omega fraternity and was a charter member and a past president of the Lions Club of Raleigh. He served two terms as chairman, and briefly as secretary-treasurer, of the Raleigh Section, A. S. M. E., and at the time of his death was secretary-treasurer of the North Carolina Society of Engineers and secretary of the North Carolina Engineering Council. He was

a member of the 1934 Nominating Committee of the A. S. M. E. from Group IV, and served as secretary of this committee. He was also a member of the Committee on Aeronautical Engineering Education of the Aeronautical Chamber of Commerce.

COLLEGE NOTES

Drexel Institute.—Professor Arthur Haas, of the University of Vienna, has accepted an invitation to come to Drexel Institute, Philadelphia, as visiting Professor of Physics for one term next year. Professor Haas is one of the foremost interpreters of modern physical research. He is the author of numerous books, and editor of the Willard Gibbs series of Yale University. He is a member of the faculty of the University of Vienna and has made two previous visits to this country. It is planned that Professor Haas will deliver the annual Alexander Van Rensselaer Lecture, give certain alumni lectures, and offer a regular course to advanced students in Physics and Electrical Engineering at Drexel.

Northeastern University.—Professor James W. Ingalls, Head of the Industrial Engineering Department, who has been in ill health for some time, has been granted leave of absence during which Professor Asa S. Knowles will be Acting Chairman of the Industrial Engineering Department. Professor Knowles will also be in charge of a new curriculum offering in Engineering Administration which will be made available to students in all engineering curricula beginning in the fall of 1936. The curriculum in Industrial Engineering with minor changes in the course content will be retained. In addition, a program in engineering and business administration leading to the degree of Bachelor of Science in Engineering Administration will be made available for students who have completed three years in Civil, Electrical, or Chemical Engineering and who wish to transfer their study as juniors and seniors to the field of management. Among the important courses included in the option in Engineering Administration are: Industrial Management, Psychology, Industrial Accounting, Cost Accounting, Statistics, Economic Geography, Public Utility Administration, Law of Contracts, Industrial Purchasing, Methods Engineering, Personnel Relations, Technical Writing, and Government Controls in Industry.

Professor Henry B. Alvord, Head of the Department of Civil Engineering, has been elected Secretary of the Massachusetts Federation of Planning Boards.

Mr. Samuel A. Shalhoub, who was graduated from Northeastern University in 1932, and who has been for the last two years a member of the staff of the University of Beirut in Syria, has returned to Boston and has been appointed a graduate assistant for the remainder of this school year and for 1935–1936.

Carl D. Smith, for the past ten years Dean of the School of Business Administration in the Evening Division, has tendered his resignation to take effect next June. Dean Smith will succeed George W. Coleman as President of Babson Institute in Wellesley, Massachusetts.

SECTIONS AND BRANCHES

The **Kansas-Nebraska Section** officers and Program Committee members elected last fall at our meeting at Kansas State College in Manhattan, Kansas, were the following:

D. C. Jackson, Jr., University of Kansas, President.
M. A. Durland, Kansas State College, Secretary.

Program Committee—

M. I. Evinger, University of Nebraska, *Chairman*,
R. M. Kerchner, Kansas State College,
Earnest Boyce, University of Kansas.

Dean Dexter S. Kimball of Cornell University was the speaker at an informal luncheon meeting of the **University of Maine Section** of the Society for the Promotion of Engineering Education on January 11. He discussed "Current Problems in Engineering Education." In the afternoon Dean Kimball held conferences with various groups of the faculty and of the student body.

I. H. PRAGEMAN,
Secretary, Main Section, S. P. E. E.

Dean Carl S. Ell, Northeastern University, and Chairman of the **New England Section,** has appointed the following Committee on Program for 1935 to plan for the next annual meeting: Walter E. Farnham, Tufts College, Frank W. Garran, Dartmouth College, James A. Hall, Brown University, Theodore H. Morgan, Worcester Polytechnic Institute, Arthur E. Norton, Harvard University, Carlton E. Tucker, Massachusetts Institute of Technology, William C. White, Northeastern University.

The Committee held its first meeting at the University Club in Boston on Saturday, March 2, 1935. The Committee had before it invitations to hold the annual meeting of the New England Section at the University of Vermont and also at the Worcester Polytechnic Institute. The date for the next meeting is Saturday, October 19, 1935, and will be held at Worcester.

The Committee decided that the program should comprise group conferences on various engineering subjects in the morning, followed by a luncheon at noon, with an afternoon period devoted to some theme of general educational interest. A banquest is to be planned for the evening with a program for both members and their wives.

It is the desire of the Committee to make this meeting of special interest to the younger men in the field of engineering education.

The officers of the **Ohio Section** are Bruce D. Greenshields, Denison Univ., *Chairman;* Samuel Ward, Fenn College, F. E. Fahey, Antioch College, *Vice-Chairmen;* S. A. Barbarger, Ohio State Univ., *Secretary.*

The 1935 meeting of this Section will be held at Denison University, April 13.

S. A. HARBARGER,
Secretary

"Education for Management" was the topic presented before the second meeting of the **Purdue Branch** of the S. P. E. E., February 28, 1935, with F. L. Serviss presiding. Four papers were presented and an unusually active discussion followed.

"The Fundamentals of Industrial Management" was presented by G. H. Shepard, Head of the Department of Industrial Management. He called attention to his "thirteen" principles as chemical elements which might be added to or even further separated in the future but still form the basis of management.

"Instruction in Industrial Engineering and Personnel" was presented in a paper by J. E. Walters, Director of the Personnel Department and Professor of Industrial Management and Personnel. In his discussion, he presented a syllabus of his courses in Industrial Management and Personnel Administration.

"The Field of Management Outside of Mechanical Engineering" was interpreted by F. C. Hockema, Assistant to the President of Purdue University. He pointed out that a large number (approximately twenty per cent) of all Purdue engineering graduates in the last seven years entered executive or management fields.

"Instruction in Accounting" was described by D. S. Clark, who administers the course in General Accounting. An adequate accounting system was described as the most powerful device of wise managers, who use its signals as a guide in determining future policies.

Two authorities were invited to discuss the topic from related fields. J. A. Estey, Head of the Department of History, Economics and Government, correlated the topic with the Field of Economics. He stressed the importance of forecasting in management. A. A. Swope, of the Department of Psychology, correlated the topic with the Field of Psychology. He stressed the measurement of group attitudes. R. B. Stewart, Controller of Purdue University, gave some interesting side lights relating to industrial management and financial foresight.

A. A. Potter, Dean of Engineering and Director of the Engineering Experiment Station, who suggested the topic under discussion, showed that the major executive positions are definitely being assigned to engineers. He also announced the general scope of the work of Doctor Lillian S. Gilbreth, eminent industrial engineer, who will be identified with the Purdue University Faculty next year.

The installation of an Indiana-Illinois Section of the S. P. E. E. proposed by R. B. Wiley was passed unanimously. Also, since the activity of the Purdue Branch of the S. P. E. E. is of years standing, it was voted unanimously that the president of the Purdue Branch be automatically a member of the executive board of the proposed section. The first meeting of the proposed section is to be held at Purdue University, April 6, 1935. This will include Armour Institute of Technology, the University of Illinois, Purdue University, Rose Polytechnic Institute, and individual members of other schools of Illinois and Indiana.

D. S. CLARK,
Secretary

BOOK REVIEWS

Direct Current Machinery. 1st Edition. KLOEFFER, BRENNEMAN AND KERCHNER. Published by MacMillan Co. 395 pages. Price $4.00.

Contrary to the usual custom in books on this subject, the authors begin this text without first devoting several chapters to the properties and laws of electricity and magnetism.

The book is divided into 16 chapters with an appendix on units and fundamental concepts. At the end of each chapter are problems which bring out the principles discussed. After defining the term dynamo so as to include both motors and generators, the authors devote the first fifty pages to Magnetic Circuits, Machine Construction, Dynamo principles and armature windings. The magnetization curve, armature reaction, reactance voltage and interpoles are next treated under individual chapters. Discussion and explanation of dynamo characteristics, operation, and control comprise about one-quarter of the book. Later chapters treat in detail such factors as efficiency, testing, rating, weights, and costs. Typical curves, tables and diagrams bring out important information throughout the work.

Of particular interest is the chapter devoted to special dynamos. This includes description and operating principles of the third brush generator, boosters, arc welding generator, dynamotors, ignition systems and gas-electric bus generators. A marked difference will be found between this book and other treatments of the same subject in the arrangement and manner of presentation. It should be applicable to use as a text for junior students in Electrical Engineering and is a worthy addition to the literature in the direct current field.

R. W. A.

The Art of Leadership. ORDWAY TEAD.

Intent reading of a book for purposes of review places upon the reader a responsibility for judgment which is sometimes difficult to meet. In the vast field of leadership there are many who seek constructive help in all the perplexities which surround their action. All are seeking a sound philosophy as a foundation for this leader-follower relationship. Does Ordway Tead's book build these sure foundations? It is believed that it does.

An intensive student of human relations and a keen observer, Mr. Tead has approached the subject of the art of leadership with originality and force. As indicated in his preface, his purpose is to set forth the meaning and methods of leadership, as contrasted with the concept and methods of command which have so long prevailed in organized human affairs. The organization of his material is excellent and is so presented that the reader is led to read himself into situations. The leader's objectives must tend always toward a worthy purpose and set a goal which his followers find desirable. The qualities necessary in leaders are defined in their personal sense. Assuming technical proficiency, he lays great stress upon a sense of purpose and direction, enthusiasm, decisiveness, integrity, and without apology, emphasizes friendliness and affection toward the followers. One gets the impression throughout all he has written that leadership is, after all, an educational process, bent on promoting efficiency, harmony, and security through understanding.

Without overemphasis, he develops some of the techniques in this learning process. The problems of women leaders are dealt with sympathetically in a separate chapter. With frank acceptance of some of her limitations, he nevertheless pays high tribute to her fine qualities: "To every leader's capacity to energize and focus purposefulness, she peculiarly has the chance to add the exercise of her power of personal interest and human understanding, of her natural directness of individual approach and affection."

One of the strong chapters of the book is "The Leader's Deeper Resources." With the reticence of a layman and yet with fervor, he calls upon the leader to have faith and a firm conviction that effort is worth while. He should believe in some meaning in human living, in some fruitful outcome of human effort, in some sense that mankind struggles, not against, but essentially in harmony with the animating power of the universe. He makes clear that this demand for a spiritual faith has always been realized by the greatest leaders. He finally makes the point that in a democratic society we must have democratic leadership, not autocratic control, not drive, but guidance, always in the direction of selfhood, vision, and adjustment. There is no question that all persons having responsibility for leadership will read this book with profit.

R. I. Rees

S. P. E. E. PIN

Many members, when notified of their election, ask for a pin. These requests have been more numerous in recent years and the Executive Committee had the following design made:

The pin is ½" with a blue background and gold lettering. It has a safety lock catch pin.

The use of the pin by the Society will come before the Council in June. If you are in favor of a pin, if you disapprove, or if you have any suggestions in regard to it, please communicate with the secretary. The prices would be:

24 karat triple gold plated	$1.00	
10 karat rolled gold	1.25	
1/10 karat gold filled	1.45	
8 karat gold	2.25	18 gauge
10 karat gold	2.55	18 gauge
14 karat gold	3.35	18 gauge
8 karat gold	1.95	20 gauge
10 karat gold	2.15	20 gauge
14 karat gold	2.80	20 gauge